

**Comparison of Electroactive Polymer (EAP) Types:**

Properties	Dielectric Electrostrictive EAP	Ion-exchange EAP	IPMC EAP
Relative speed of full cycle	≤Sec.	Minutes	Seconds
Maximum strain	100%+	Low	Moderate
Maximum efficiency	80%+	≤50%	≤50%
Operating voltage	3 to 7kV-DC	Few volts (3 to 24VDC)	Few volts (3 to 24VDC)
operating current	Micro amp.	Micro amp	Micro amp.
operating environment	Dry/Wet	Electrolyte media	Dry/Wet
Load displacement	Significant	Small	Moderate

Table A

*FIG. 1*

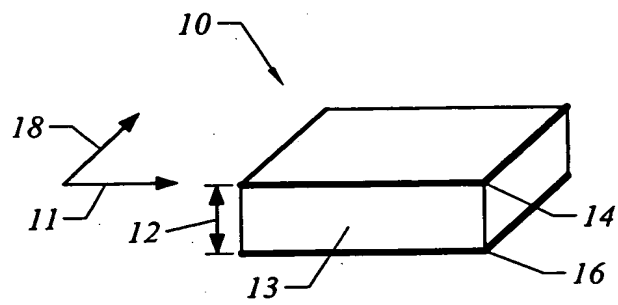
### EAP Material Requirement

Following table lists some of the material requirement for the Electroactive polymer (EAP)  
for the use as assist device and use as assist pump:

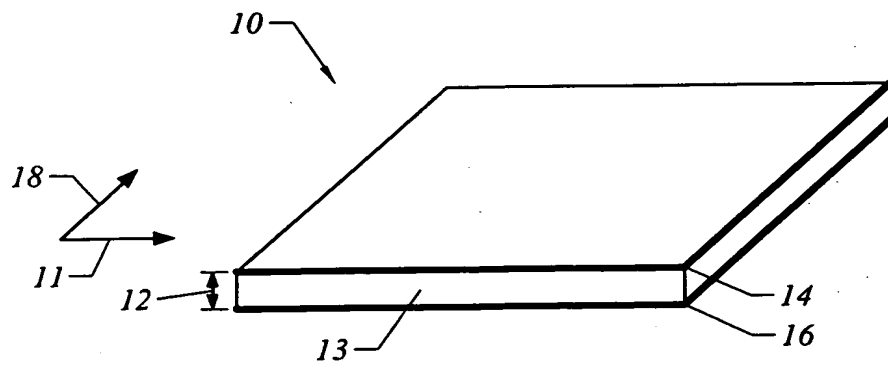
Description	Dielectric electrostrictive EAP	Ion exchange polymer metal composite
1. Base material	Silicone, Polyurethane, Latex, Styrene, Copolymers of styrene - like styrene-butadiene-styrene, Isoprene, Acrylate etc.	Ionomers like perfluorosulfonate and perfluorocarboxylate; Polyvinylidene fluoride, etc.
2. Elongation at break	600 to 1600%	50 to 500%
3. Tensile strength	2 to 60MPa	10 to 75MPa
4. Ionic conductivity	n/a	20 to 100 Volts/cm
5. Dielectric strength	1kV to 10kV per mil.	n/a
6. Hardness	3 to 50A	10 to 75A
7. Working voltage	500V to 10kV	1V to 48V
8. Working current	Micro Amp to Amp	Micro Amp to Amp
9. Electrode material	Conductive carbon, graphite, platinum, gold and silver	Conductive carbon, graphite, platinum, gold and silver
10. Electrode conductivity	Kilo-Ohm to mega-Ohm	n/a
11. Electrode placement	Conductive layer on the surface	Impregnated in the base material

Table B

*FIG. 2*



*FIG. 3A*



*FIG. 3B*

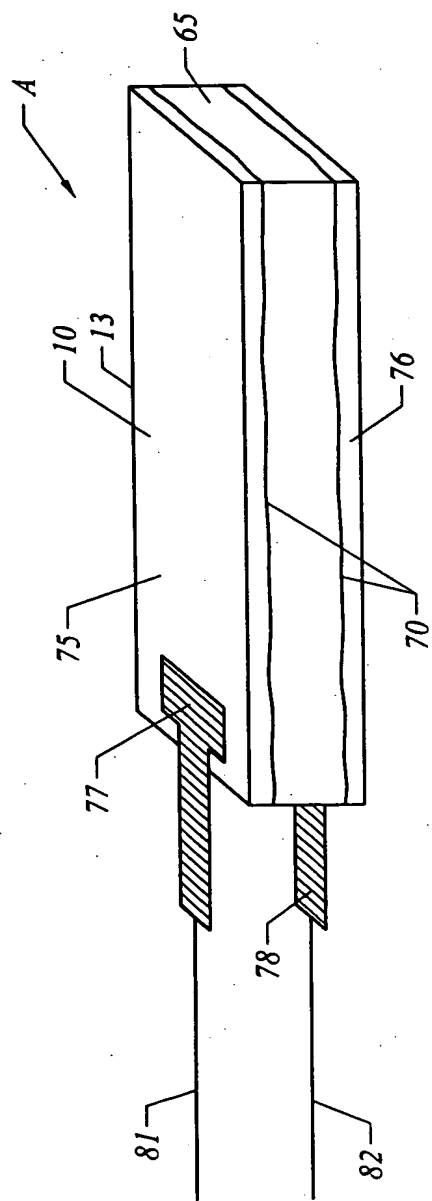


FIG. 4

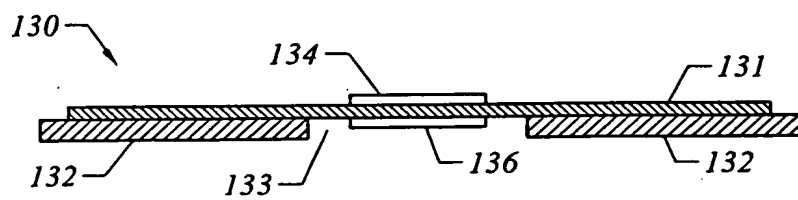


FIG. 5A

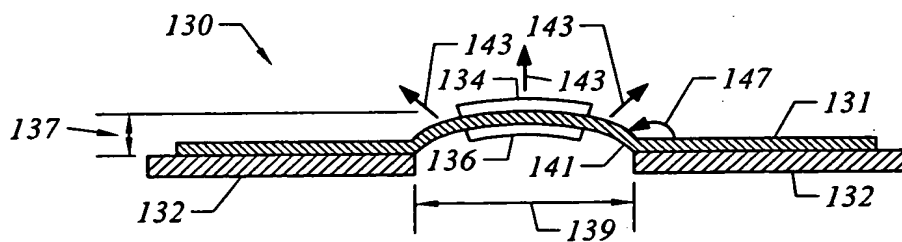


FIG. 5B

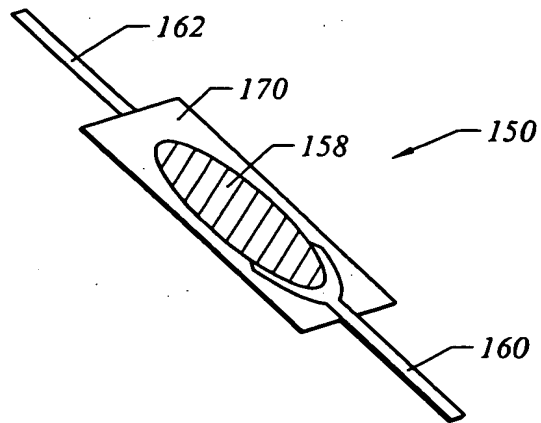


FIG. 6A

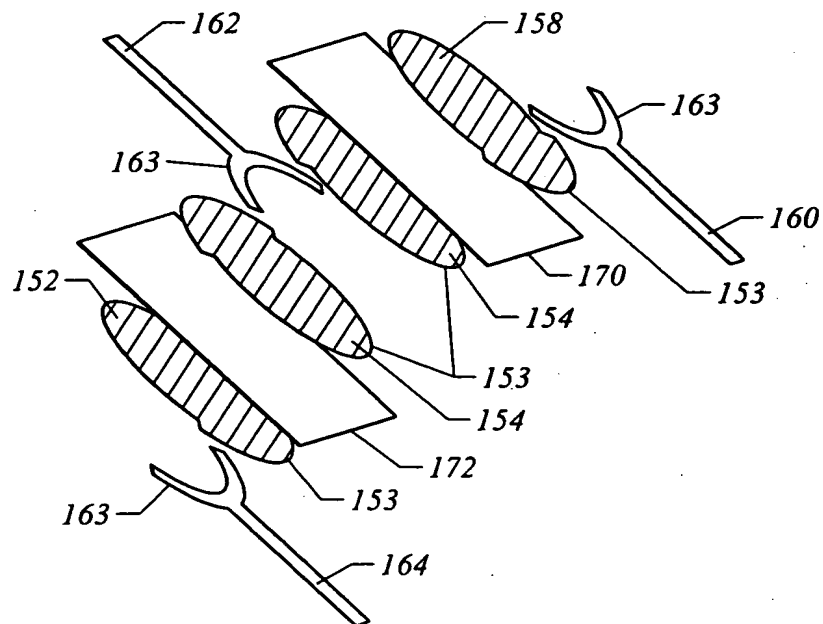


FIG. 6B

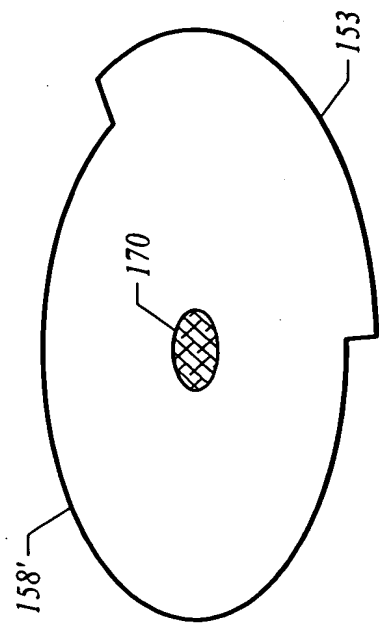


FIG. 7B

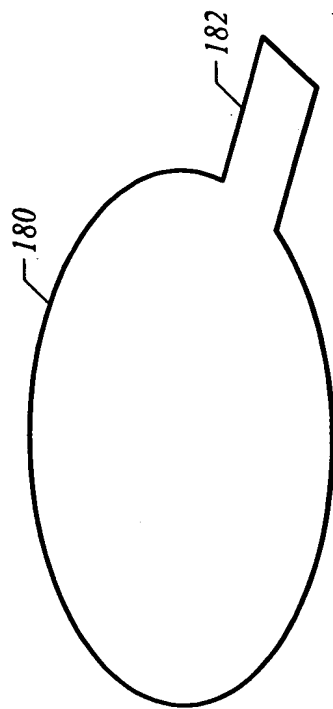


FIG. 7C

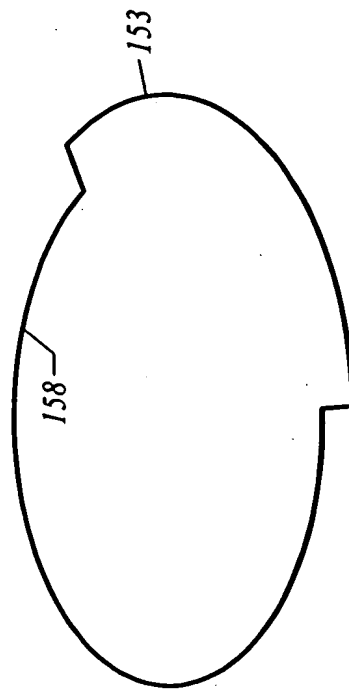


FIG. 7A

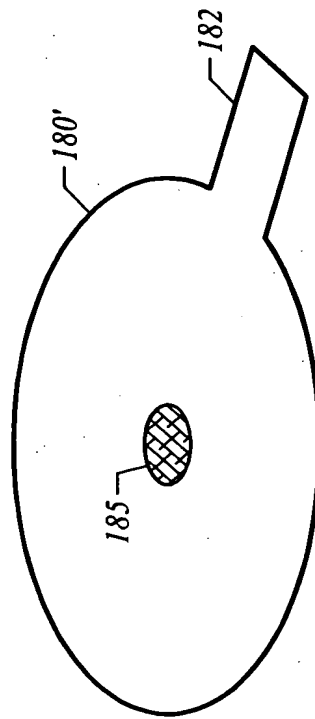


FIG. 7D

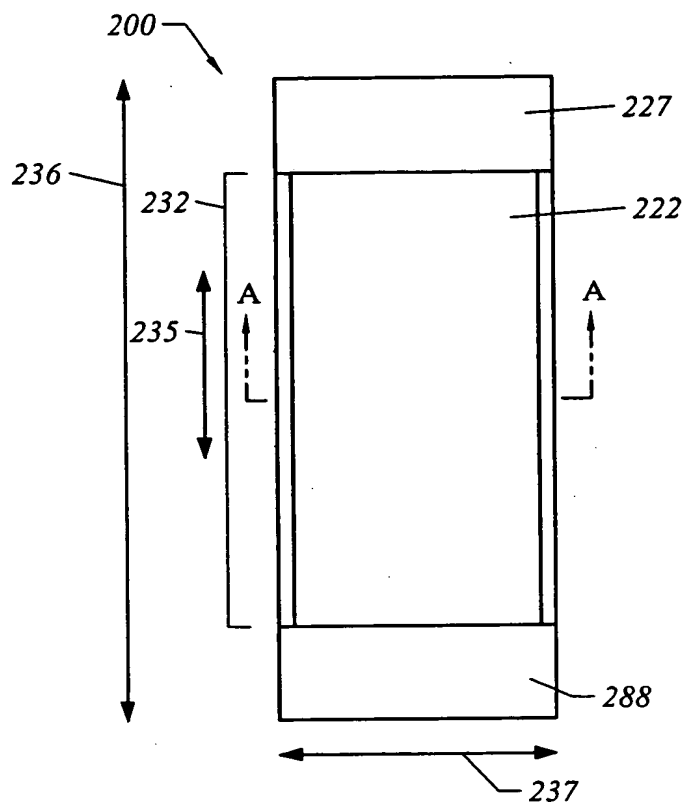


FIG. 8A

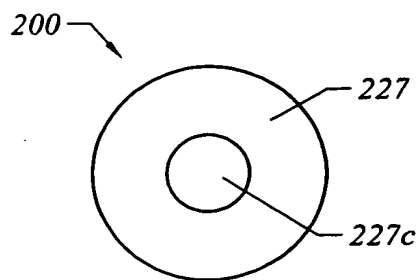
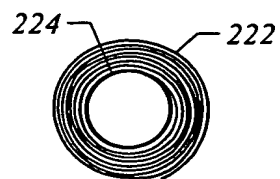


FIG. 8B



Section A-A

FIG. 8C



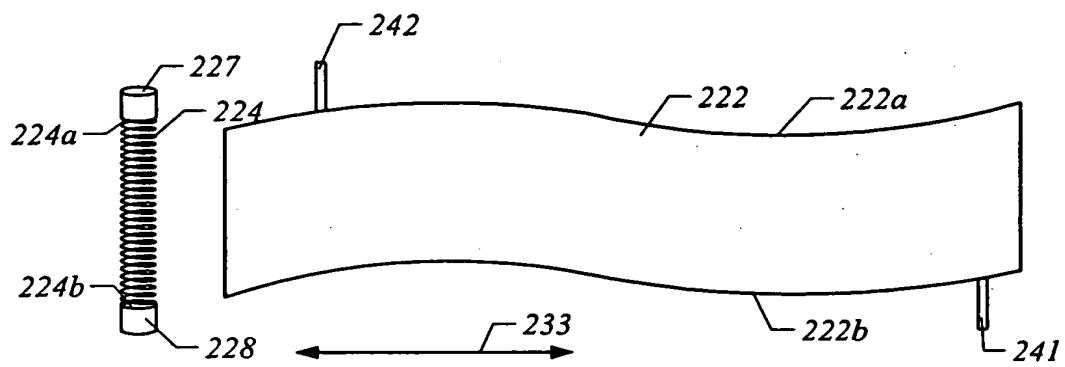


FIG. 8D

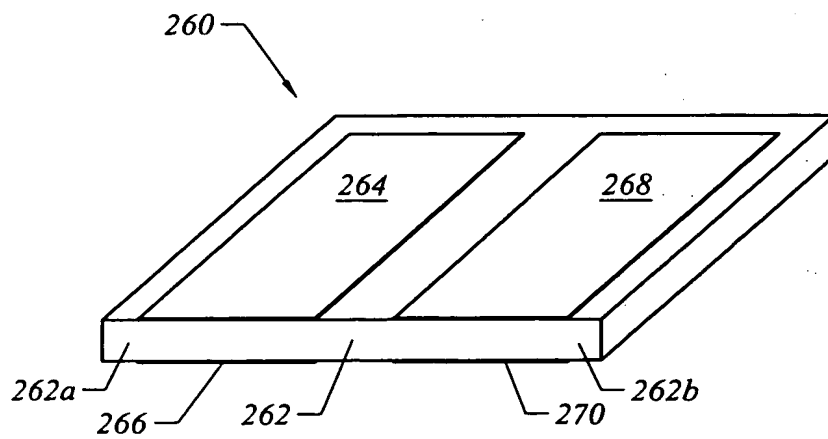


FIG. 8E

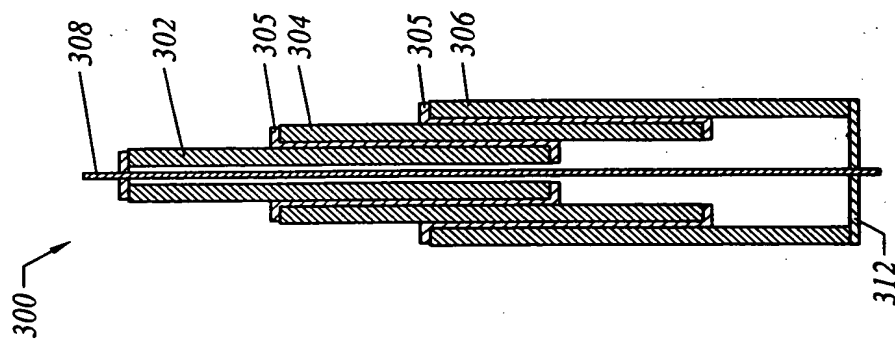


FIG. 9A

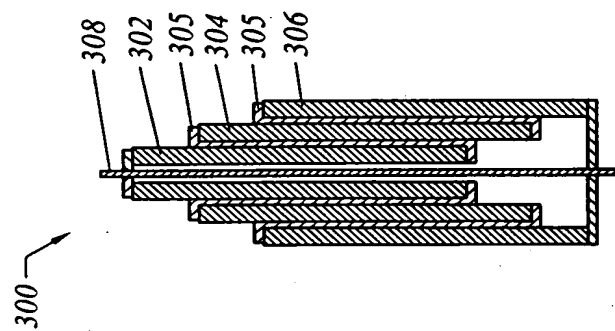


FIG. 9B

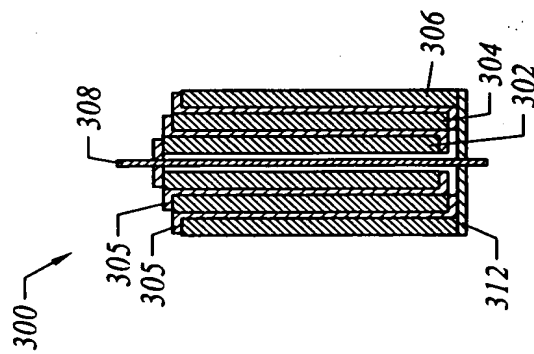
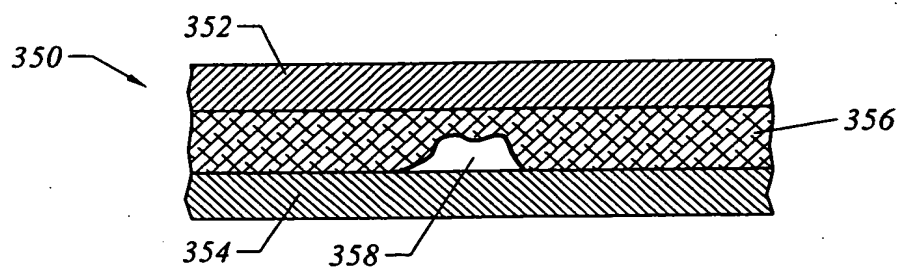
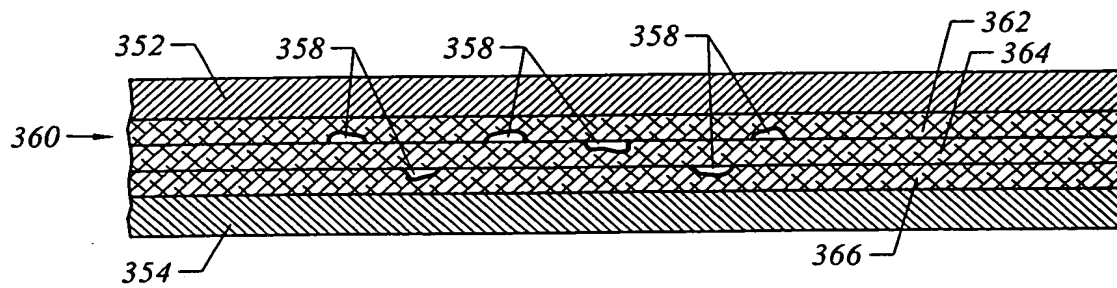


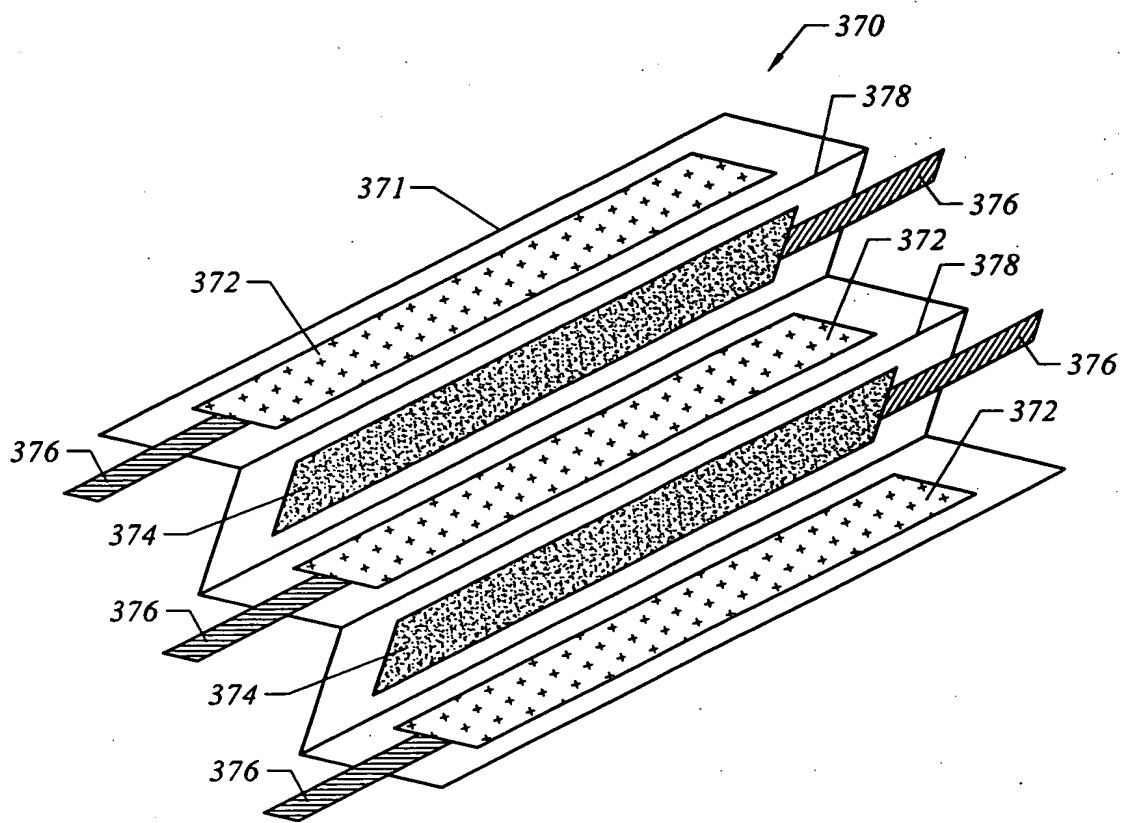
FIG. 9C



**FIG. 10A**  
(Prior Art)



**FIG. 10B**



*FIG. 11*

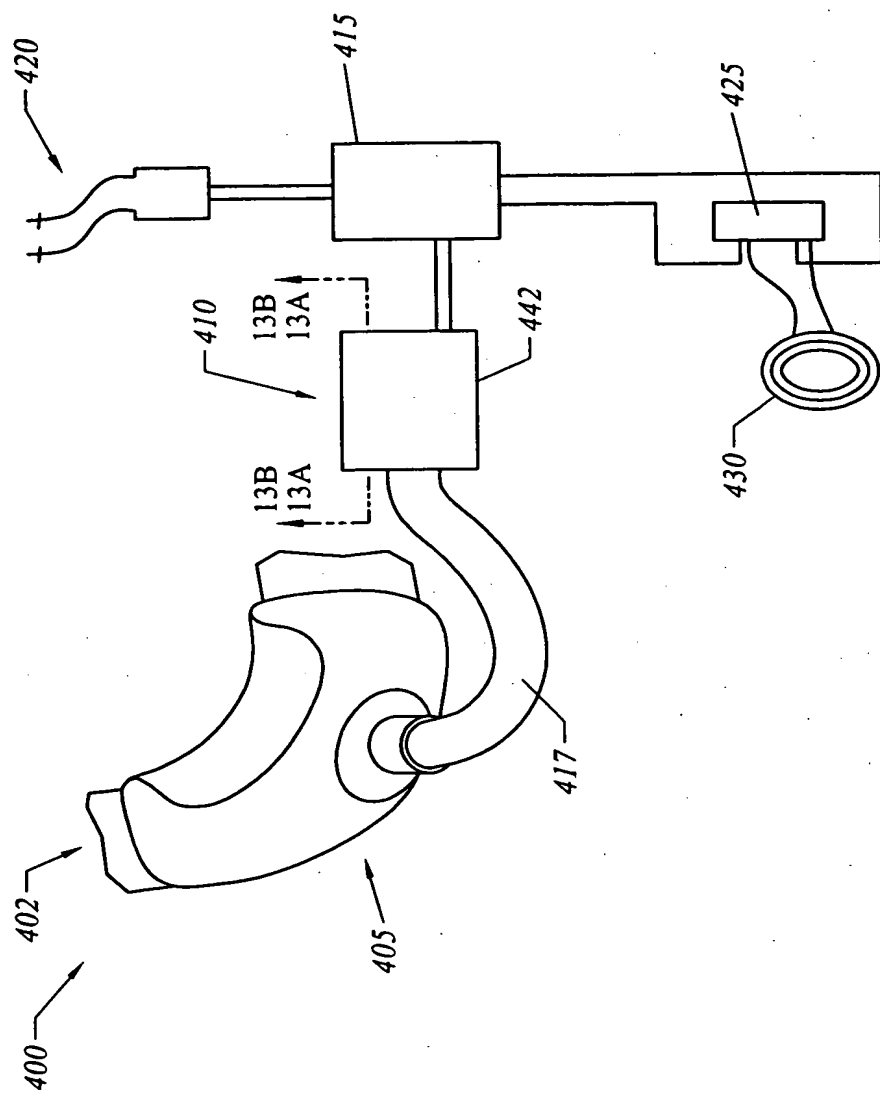


FIG. 12



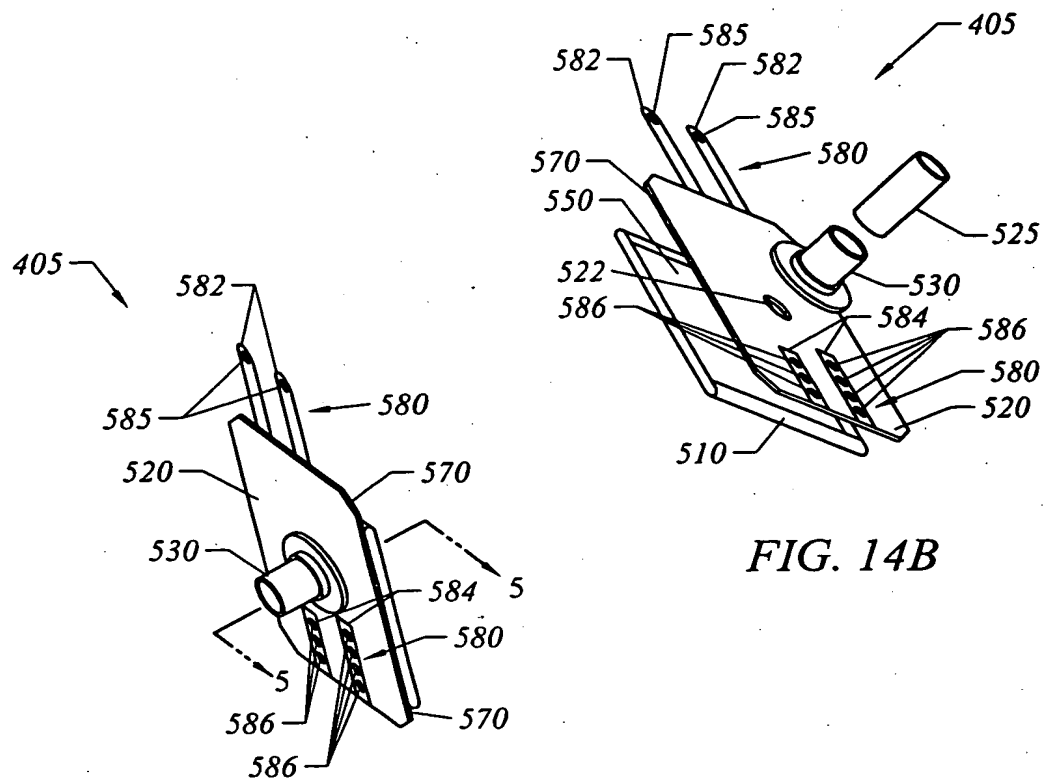


FIG. 14A

FIG. 14B

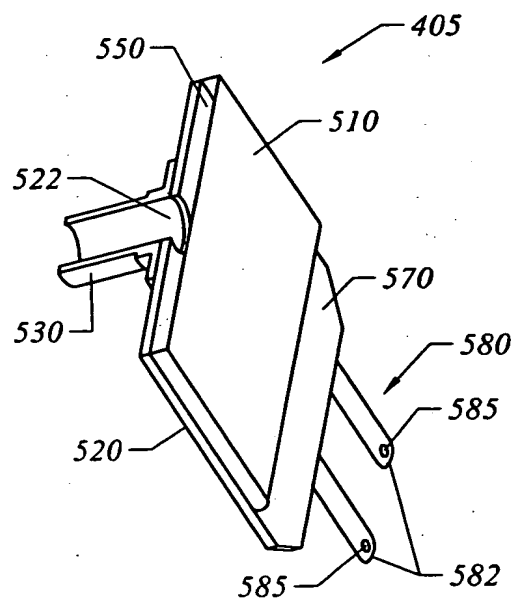
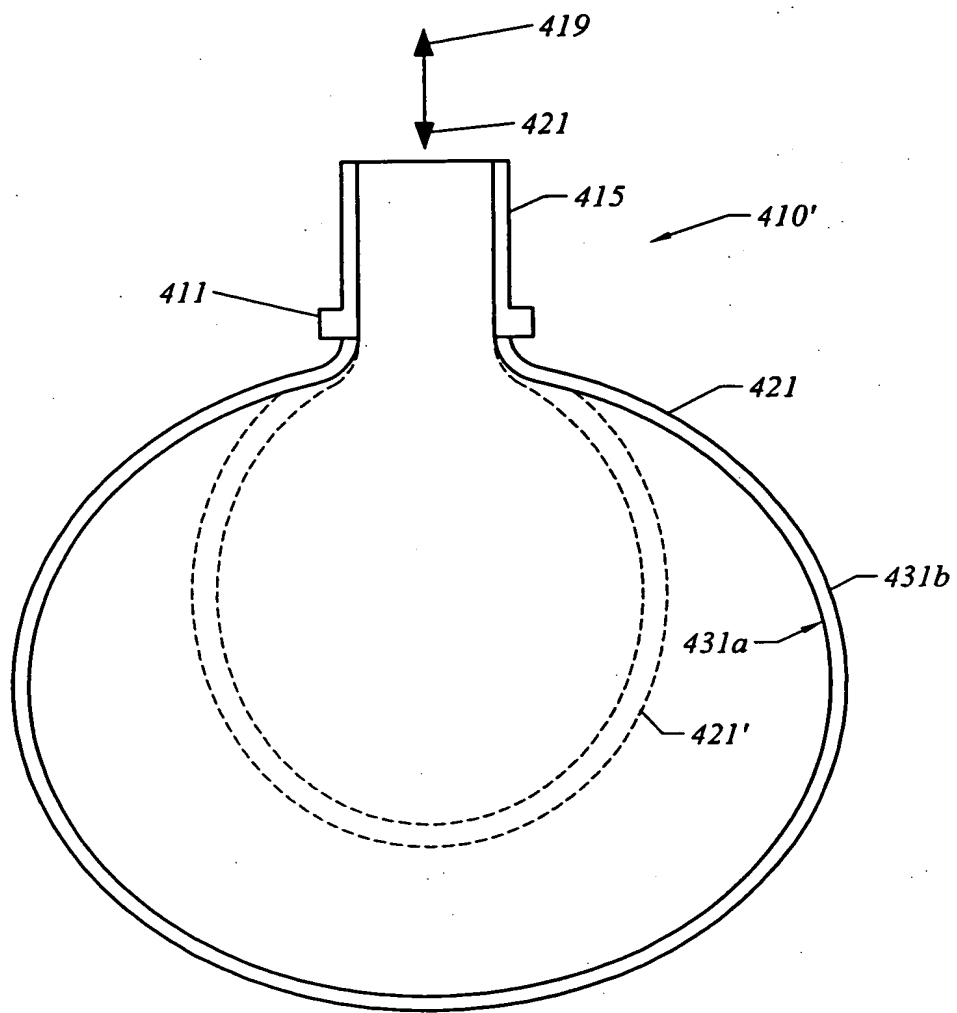


FIG. 14C



*FIG. 15*



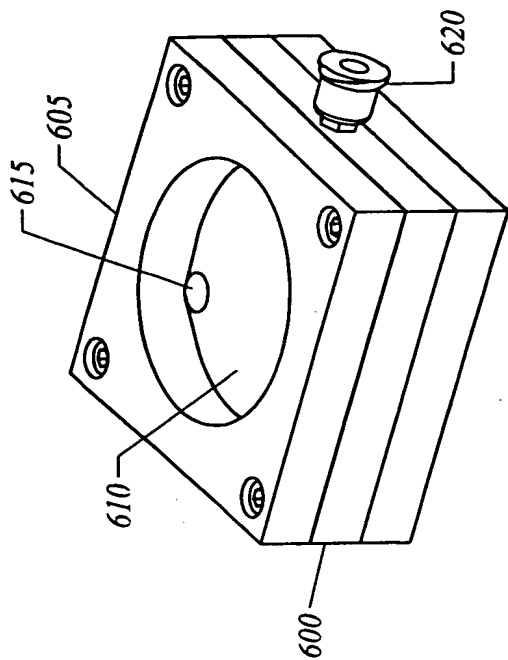


FIG. 16A

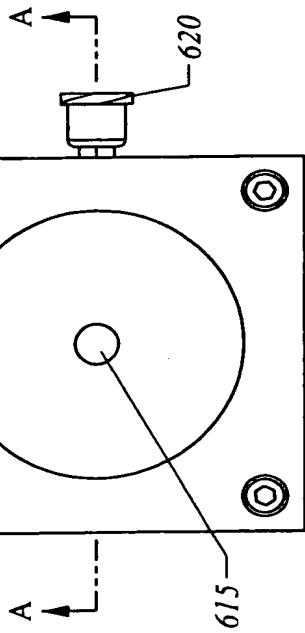


FIG. 16B

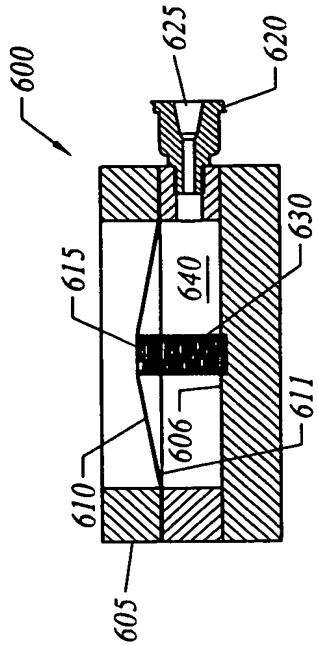


FIG. 16C

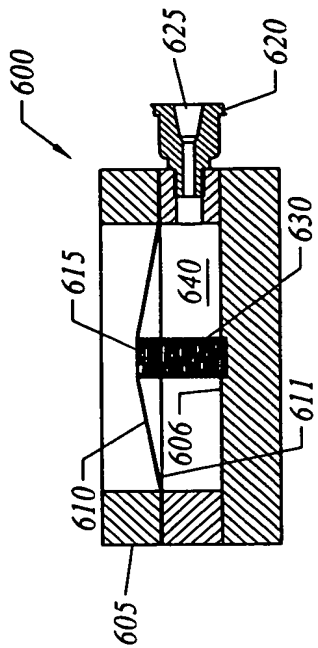
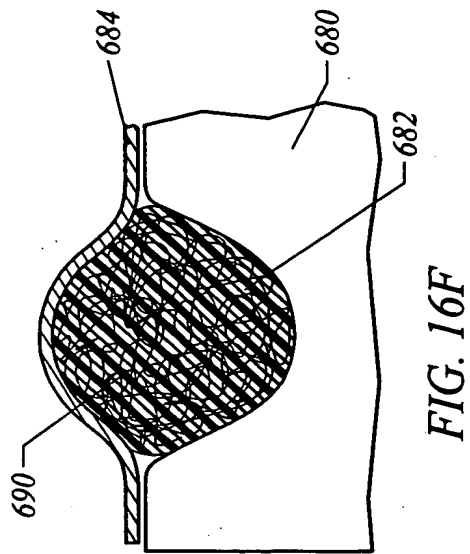
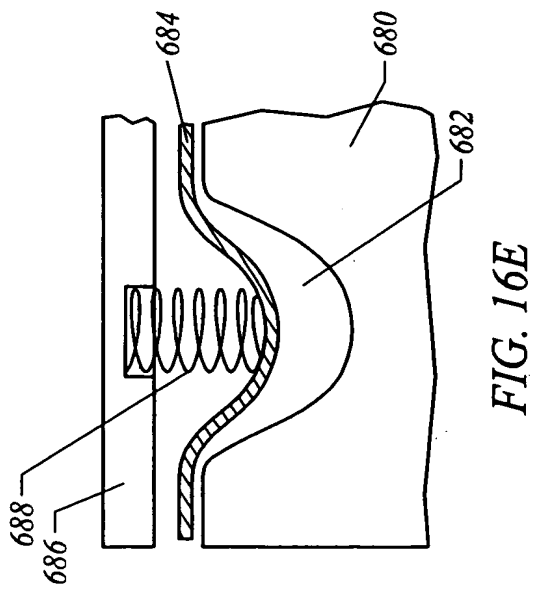


FIG. 16D



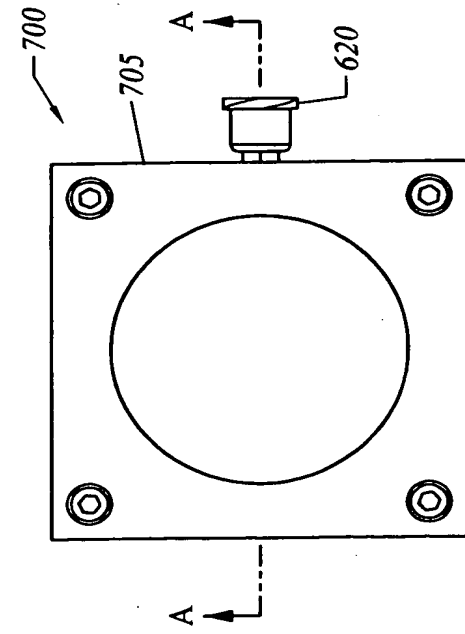


FIG. 17A

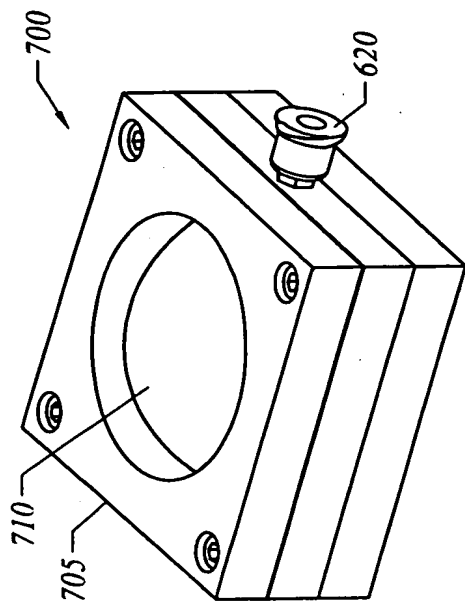


FIG. 17B

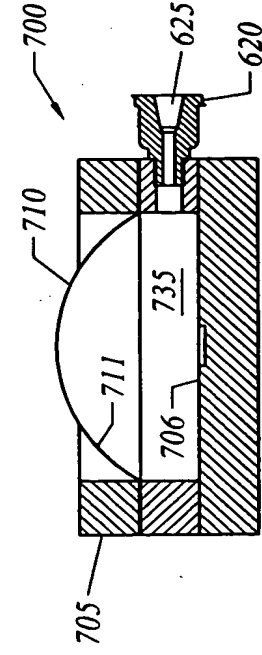


FIG. 17C

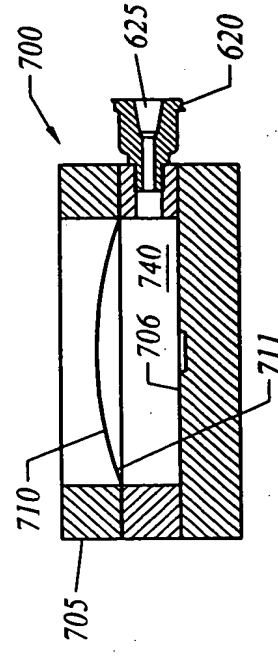


FIG. 17D

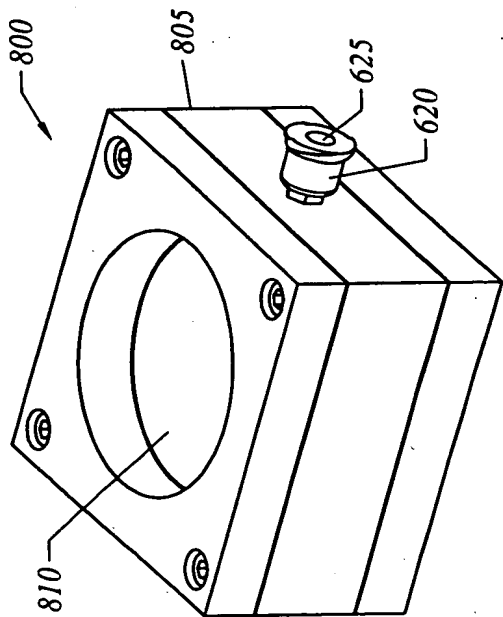


FIG. 18B

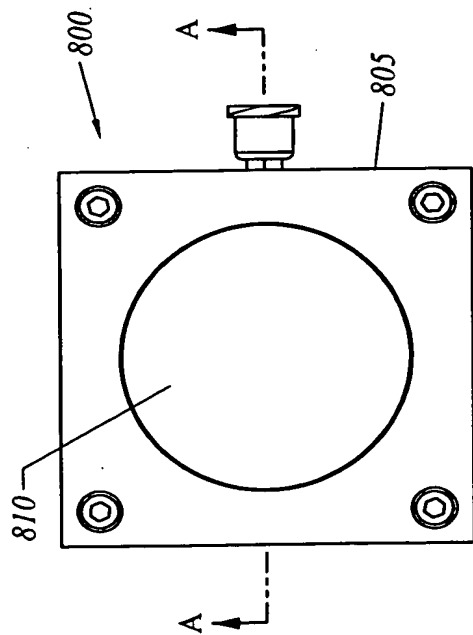


FIG. 18A

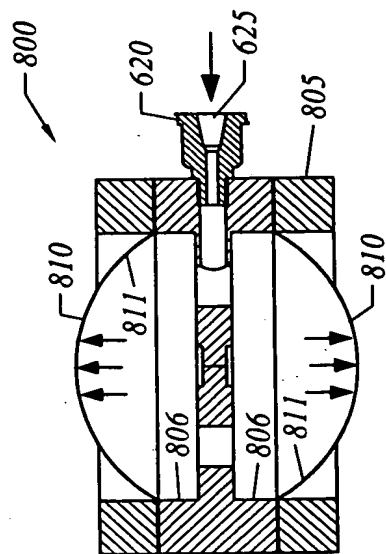


FIG. 18D

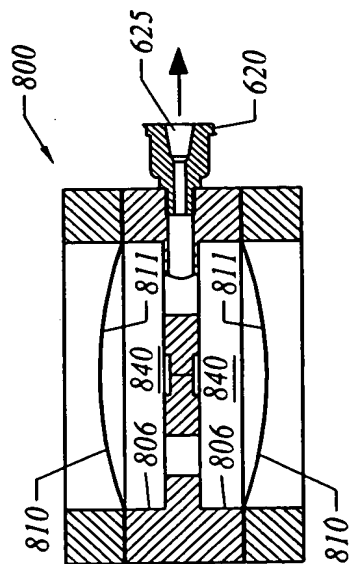


FIG. 18C

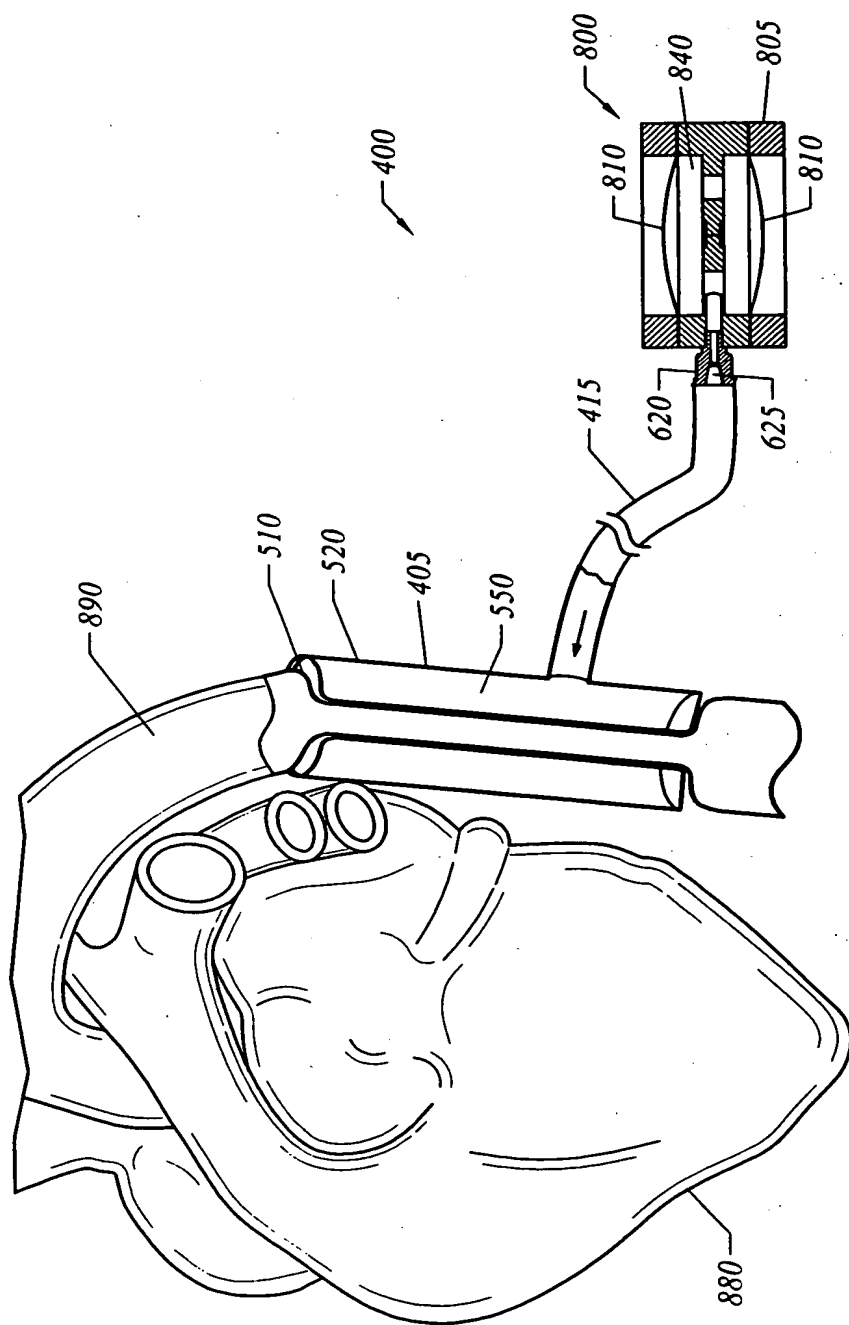


FIG. 19A

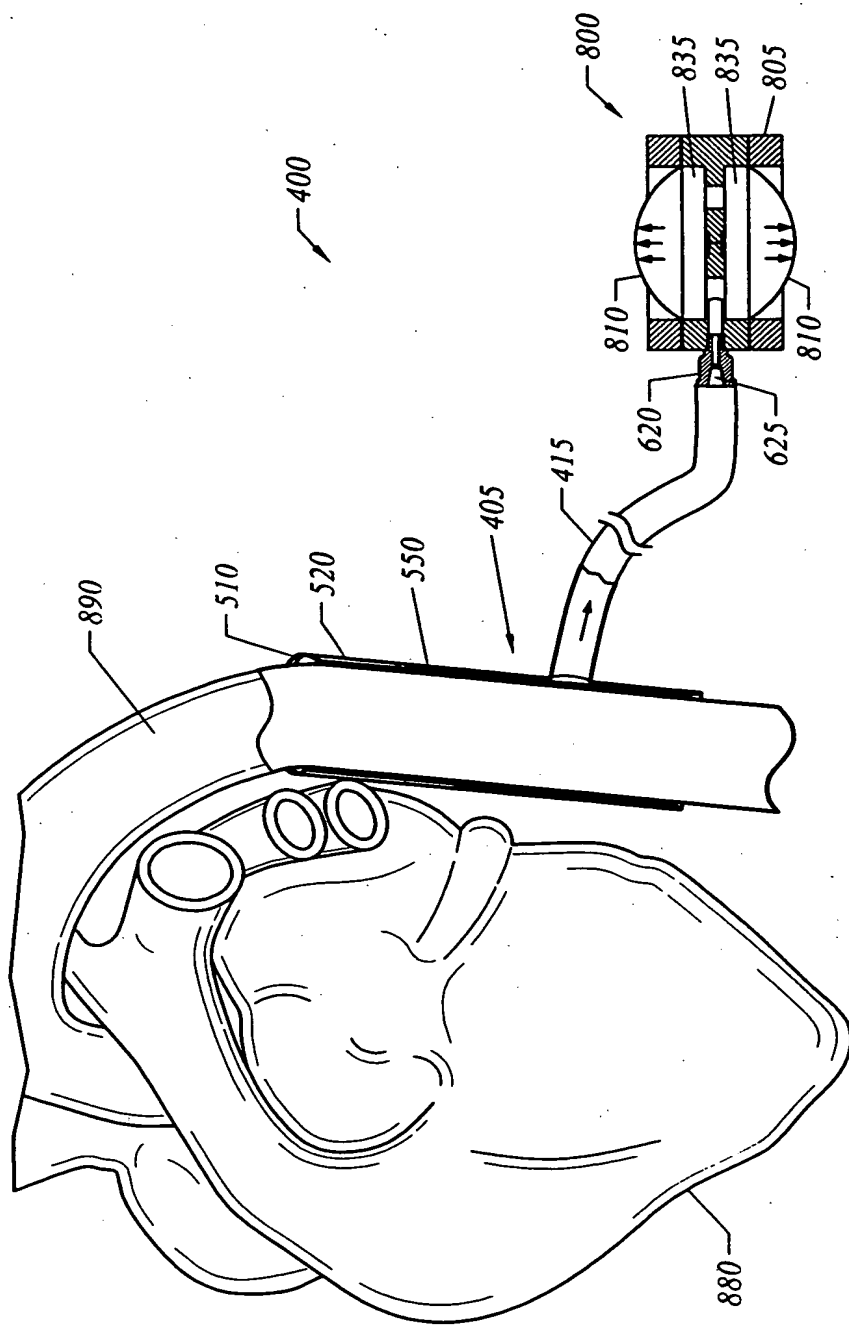


FIG. 19B

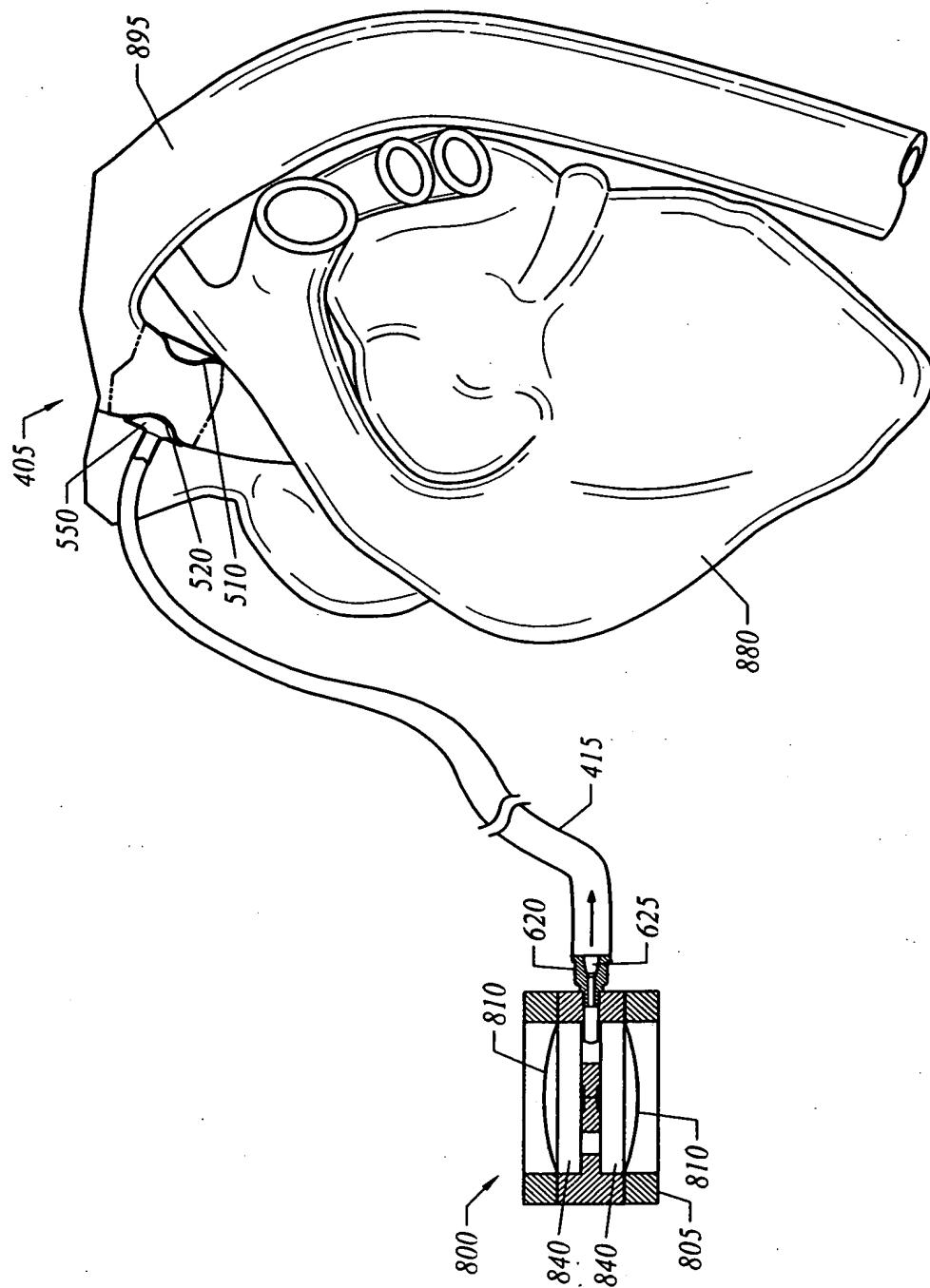


FIG. 19C

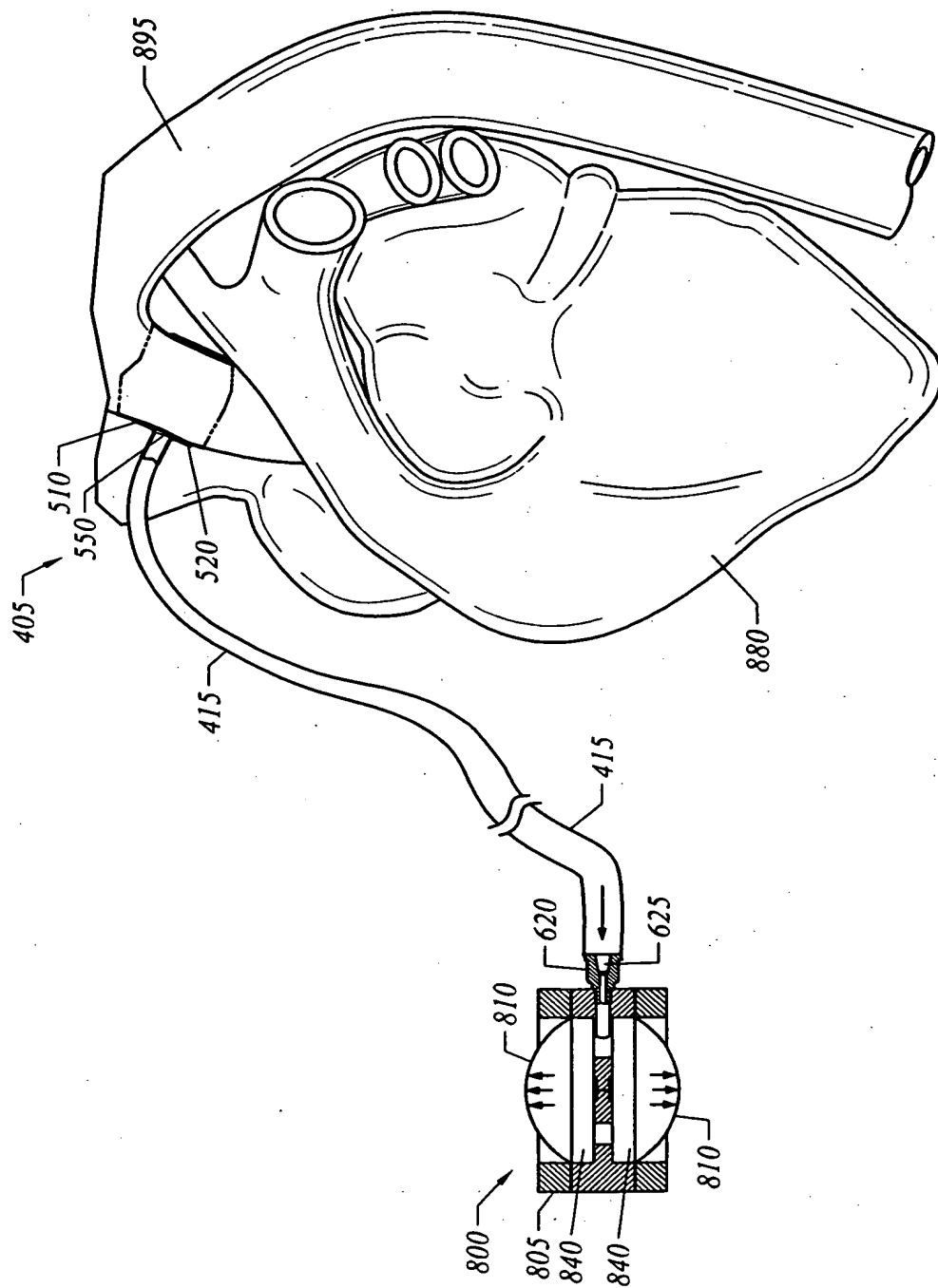
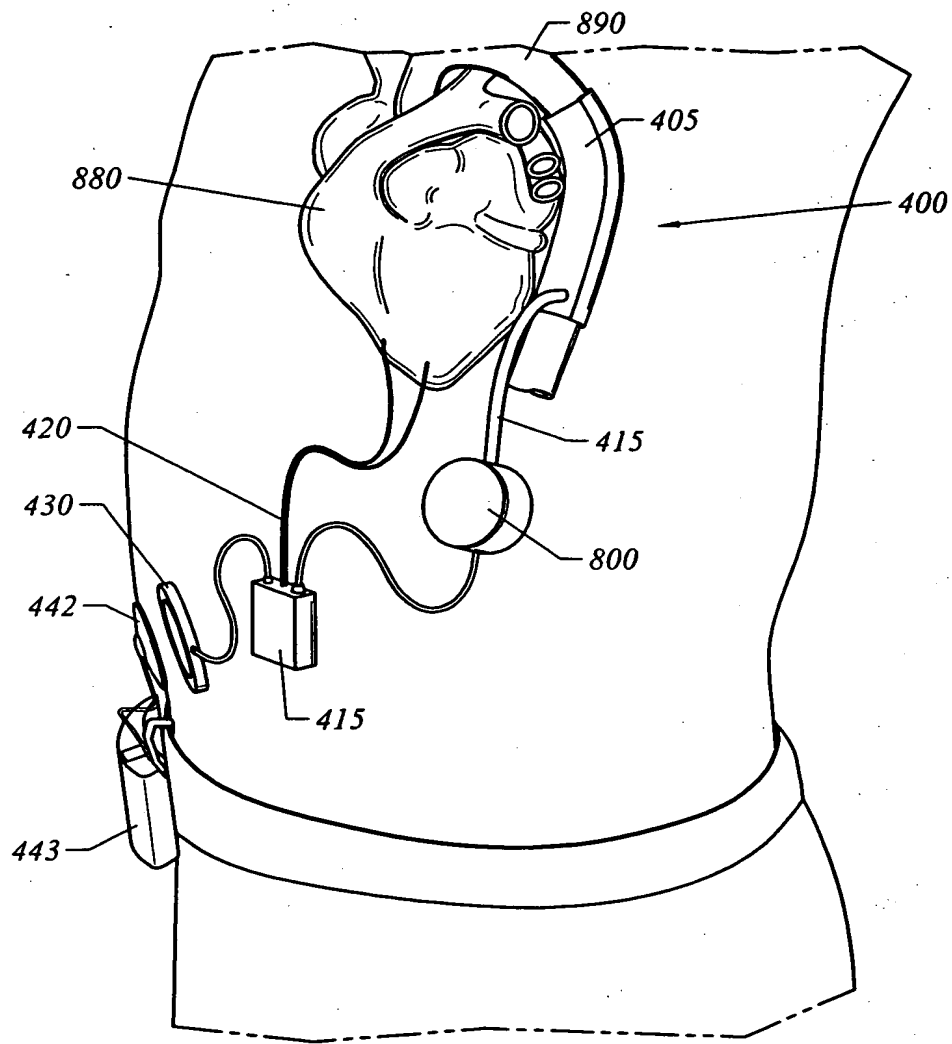


FIG. 19D





*FIG. 20*

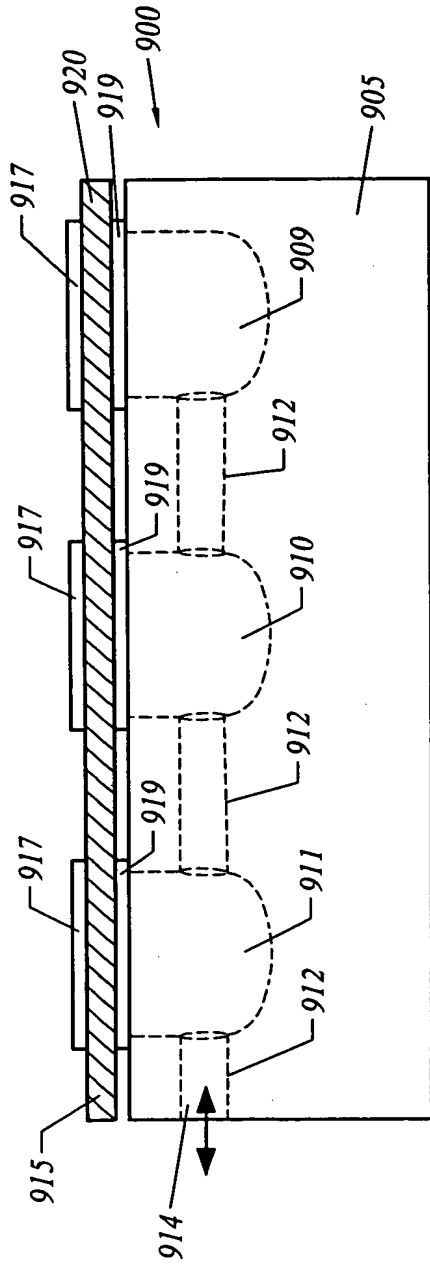


FIG. 21

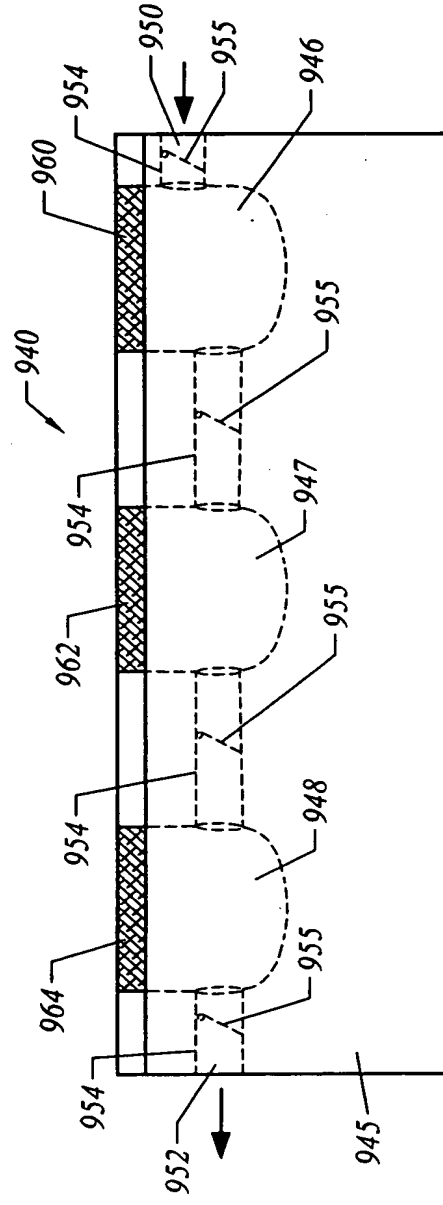
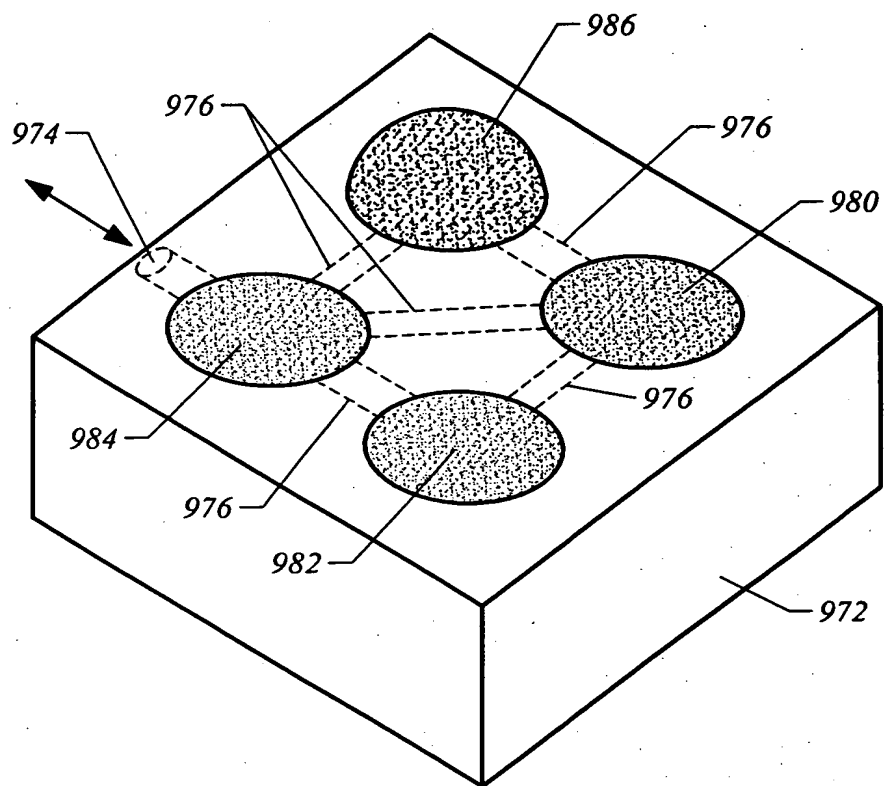


FIG. 22



*FIG. 23*

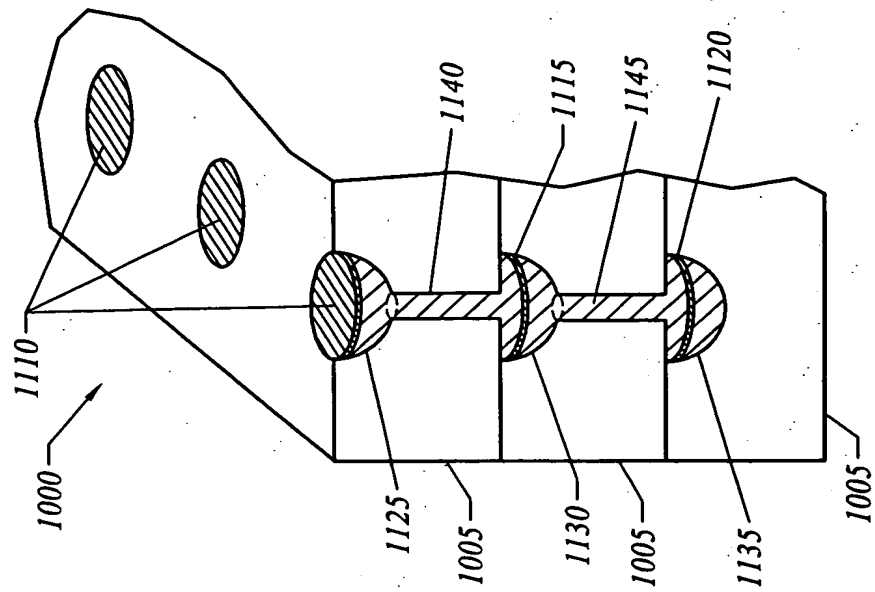


FIG. 24B

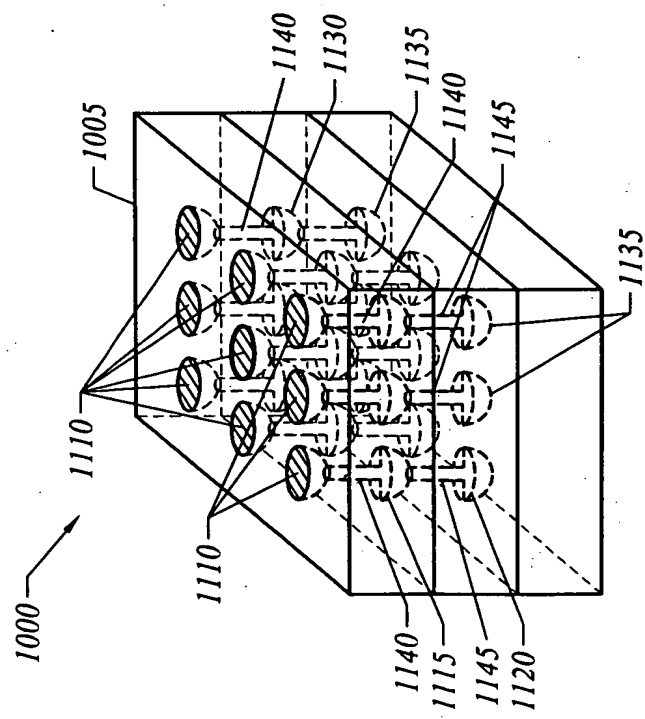


FIG. 24A

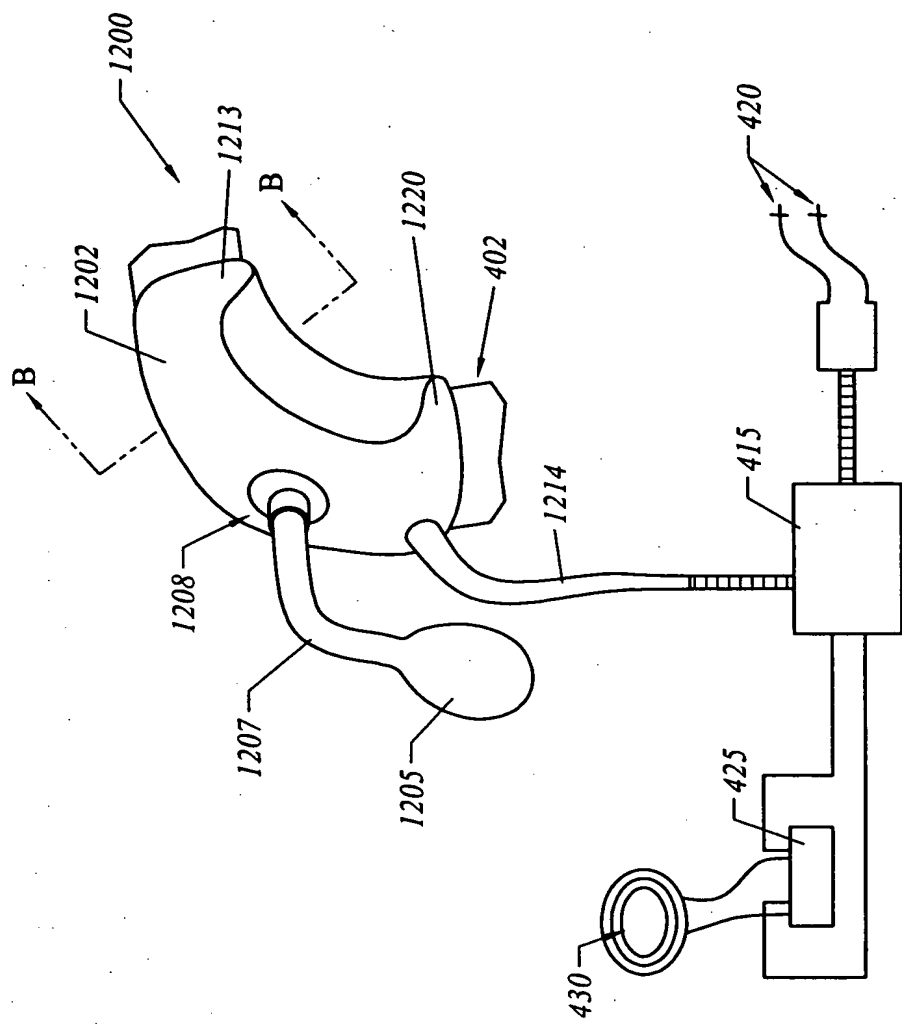


FIG. 25

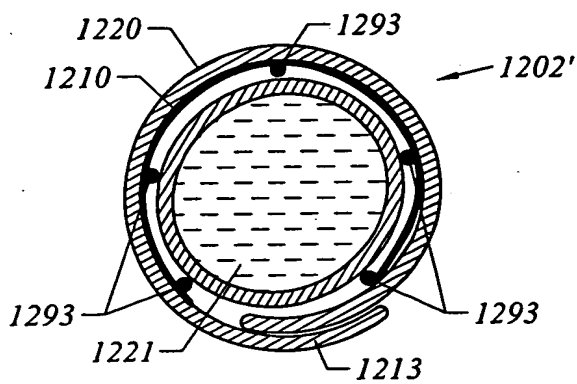


FIG. 26A

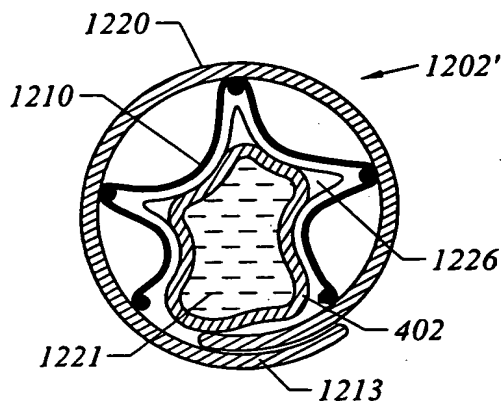


FIG. 26B

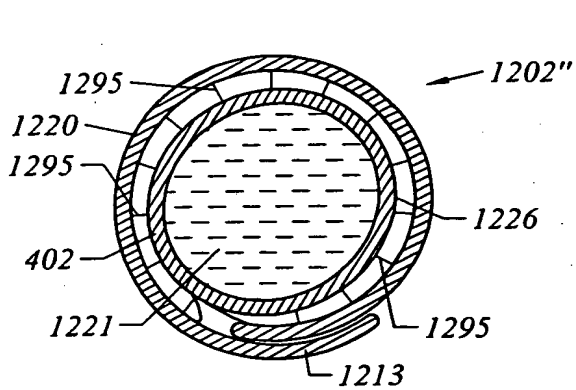


FIG. 27A

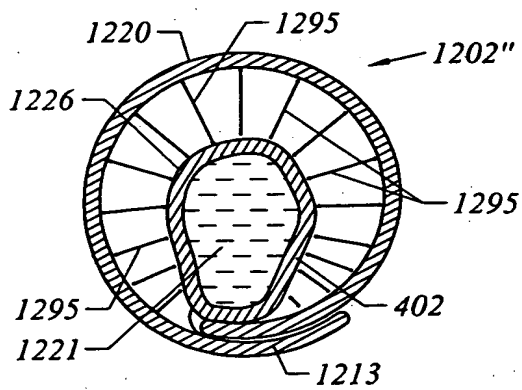


FIG. 27B

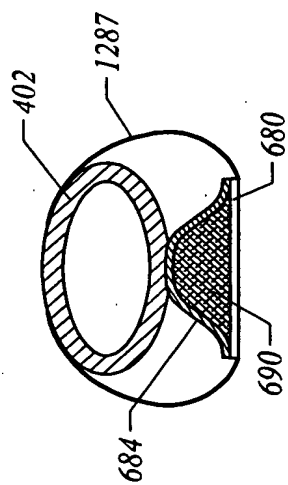


FIG. 28A

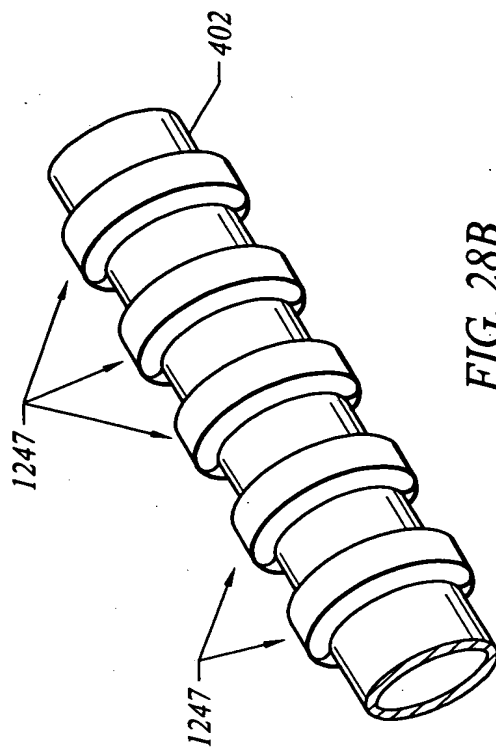


FIG. 28B

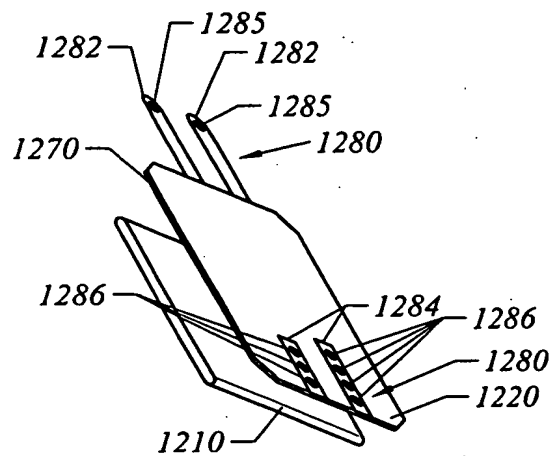


FIG. 29

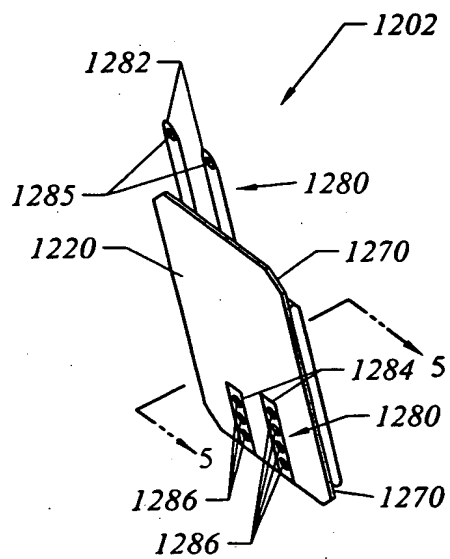


FIG. 30

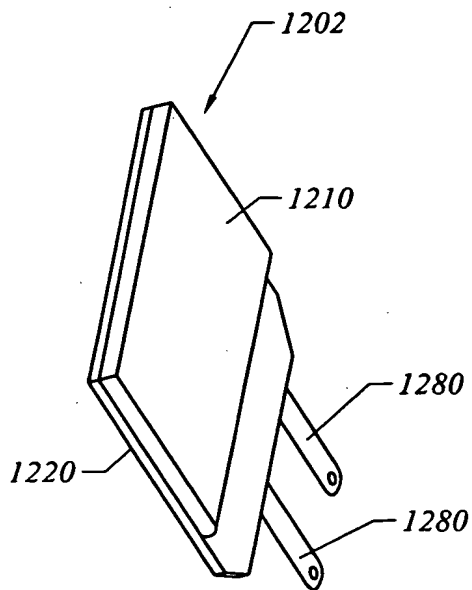
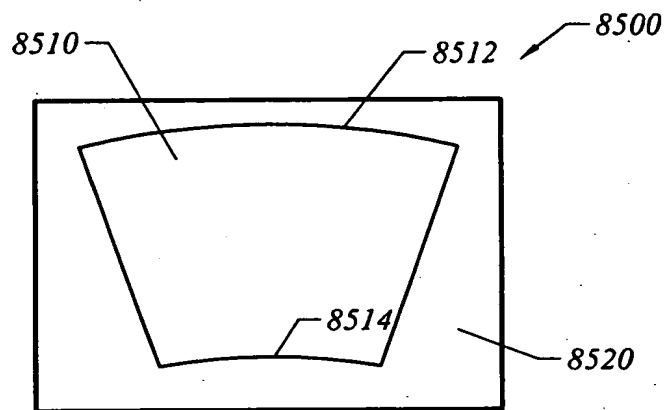
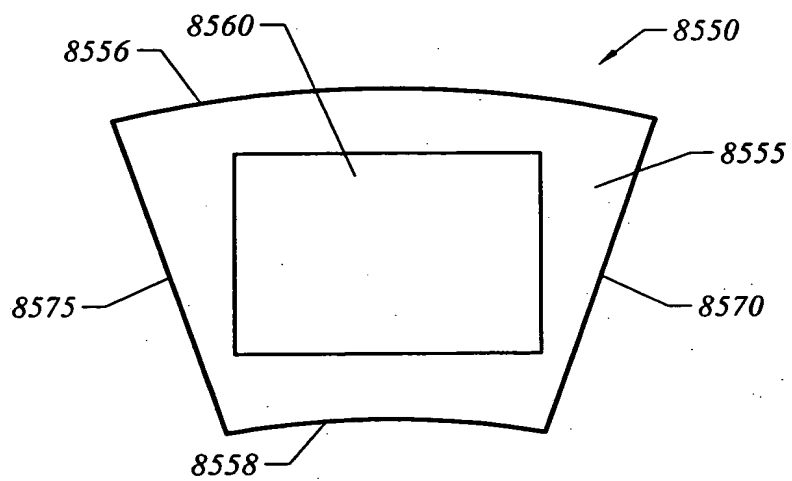


FIG. 31

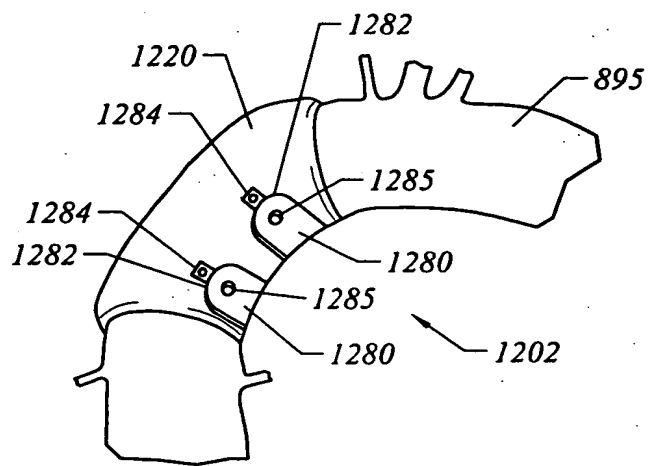




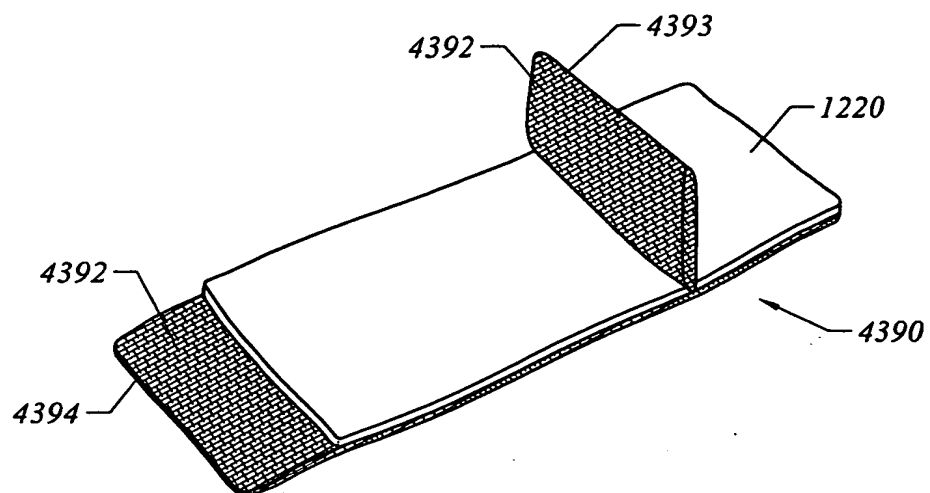
*FIG. 32A*



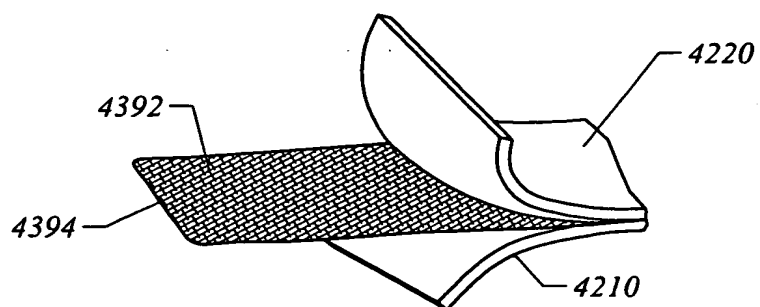
*FIG. 32B*



*FIG. 33*



*FIG. 34A*



*FIG. 34B*

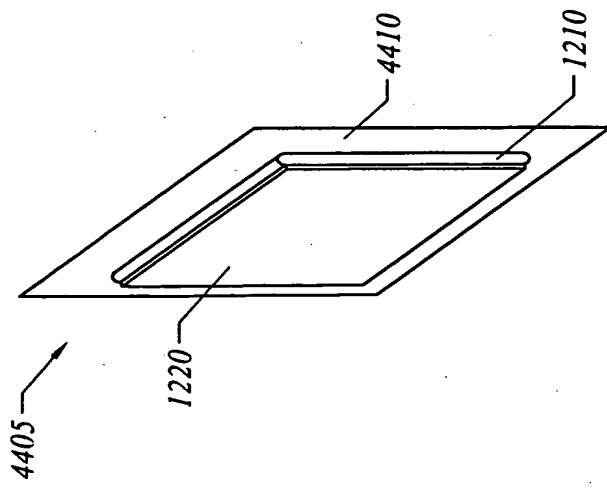


FIG. 35

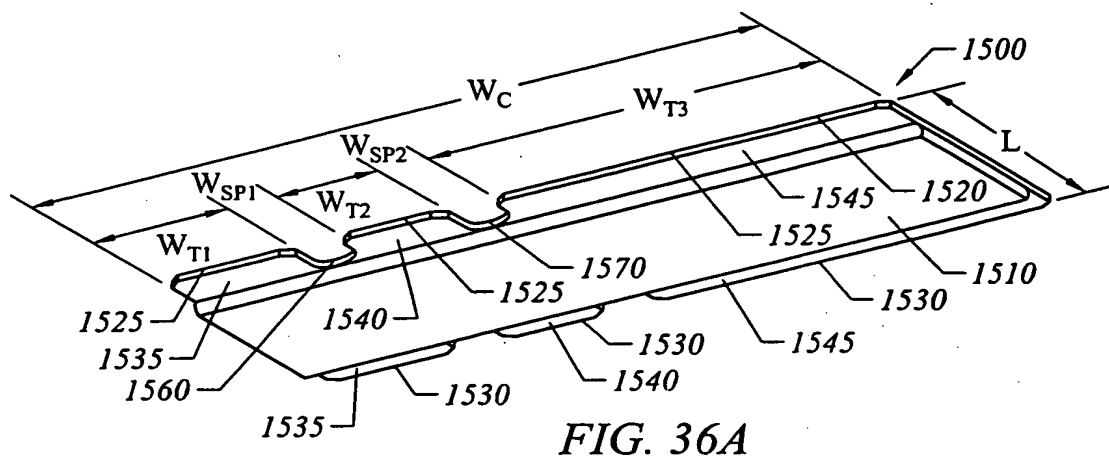


FIG. 36A

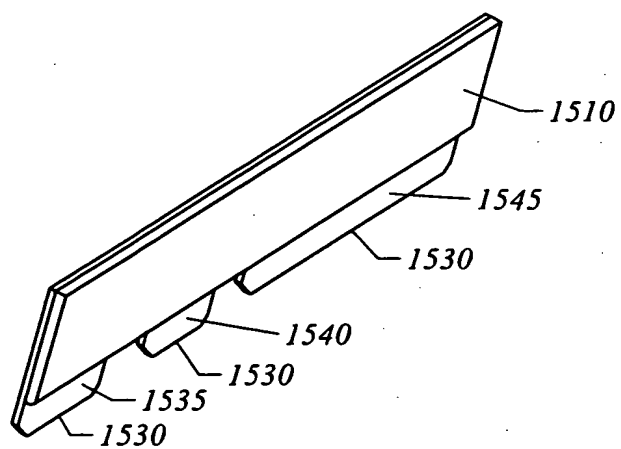
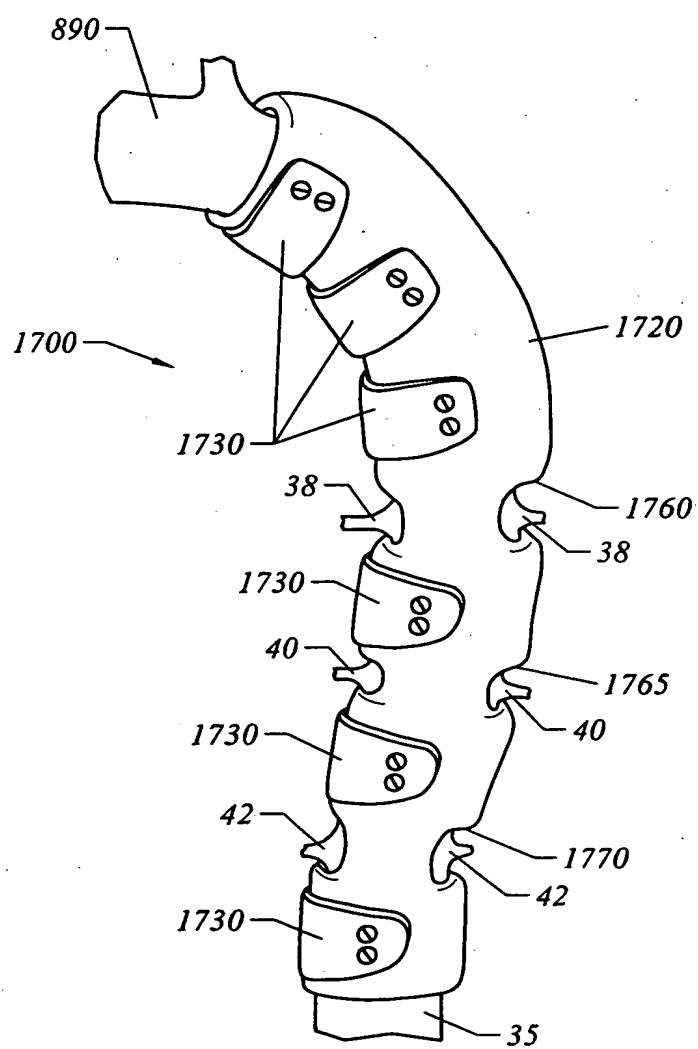
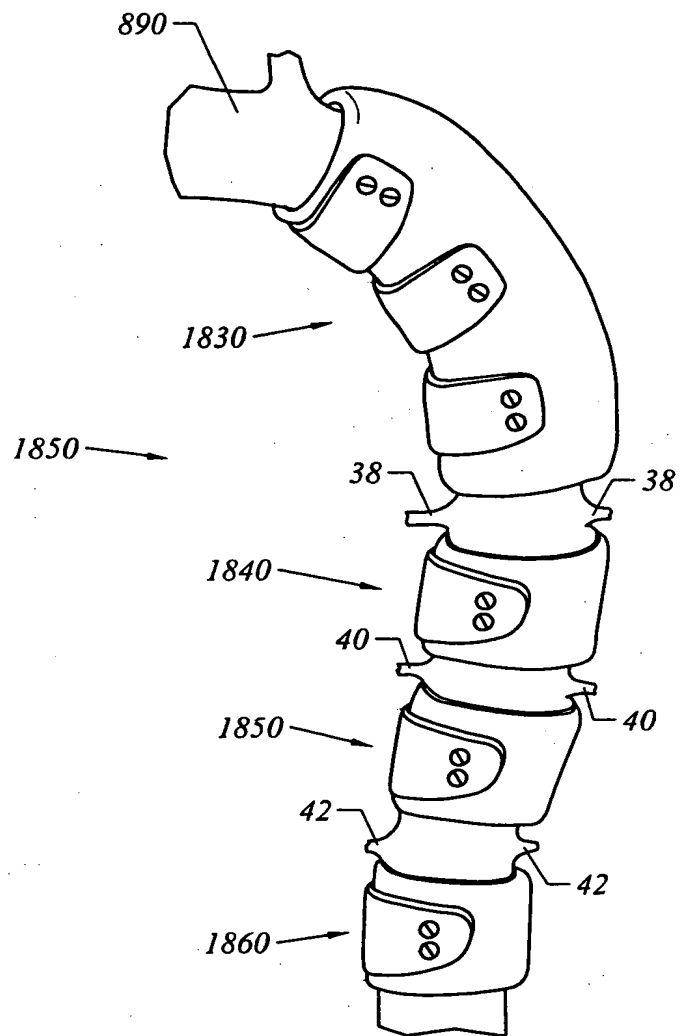


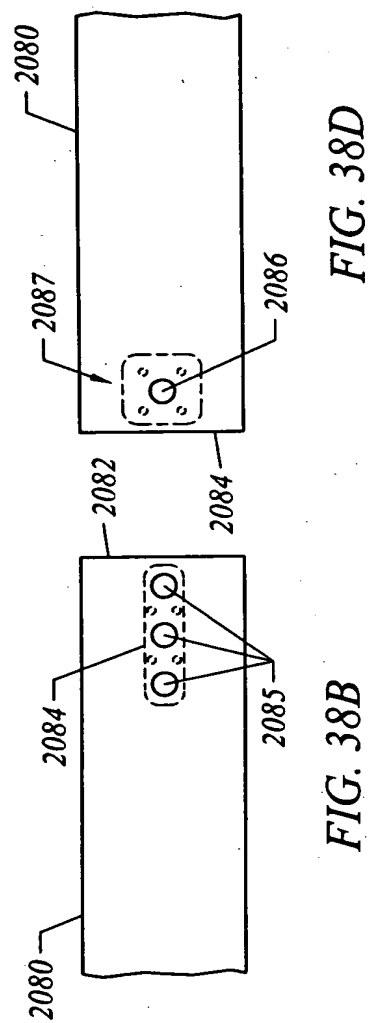
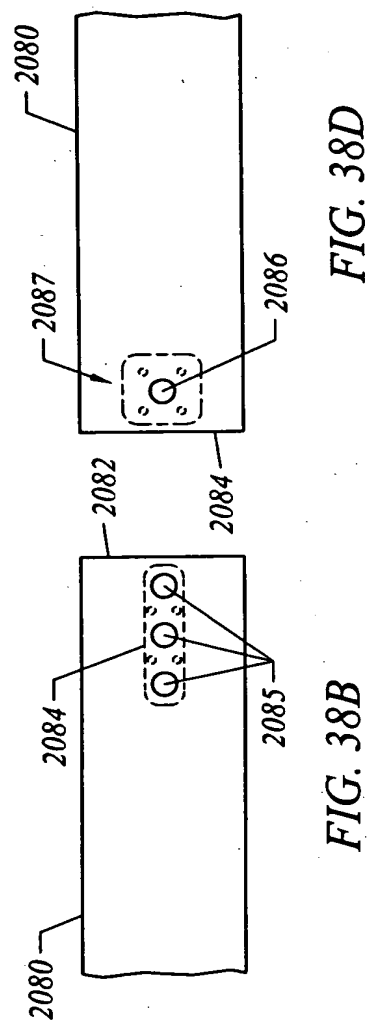
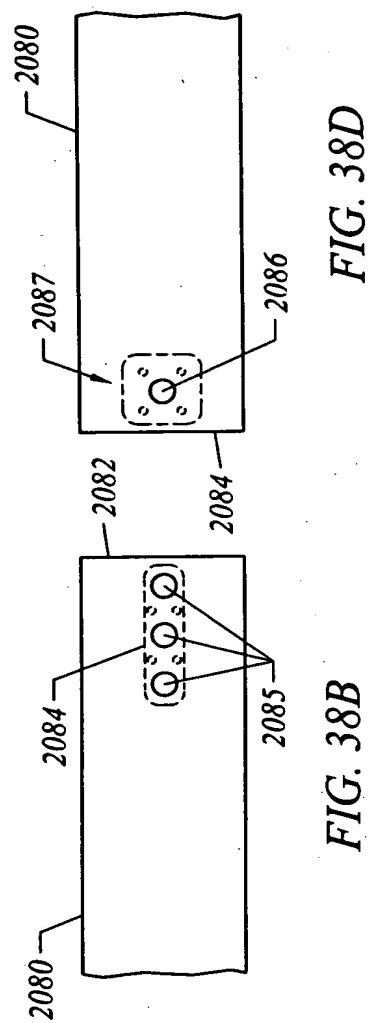
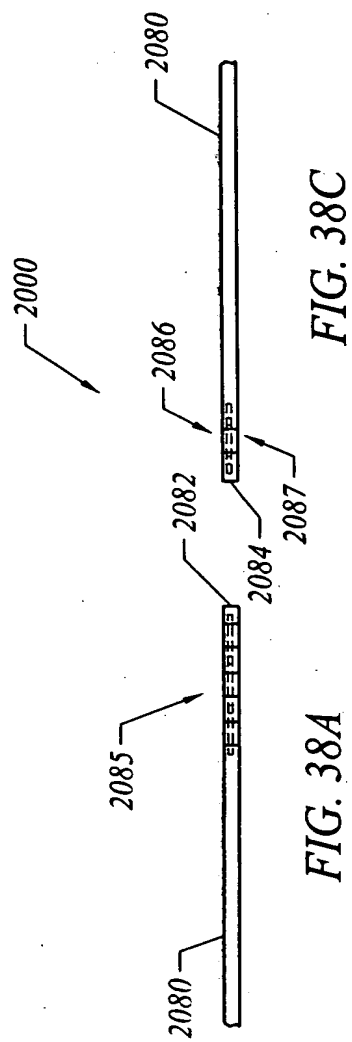
FIG. 36B



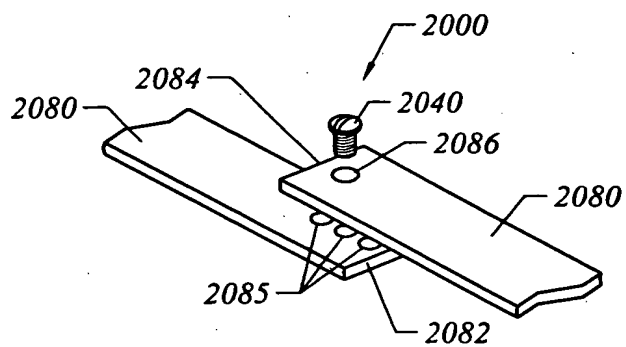
**FIG. 37A**



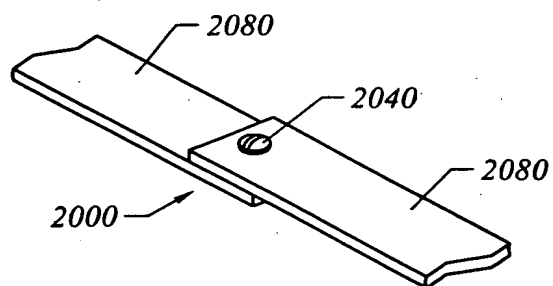
*FIG. 37B*







*FIG. 39A*



*FIG. 39B*

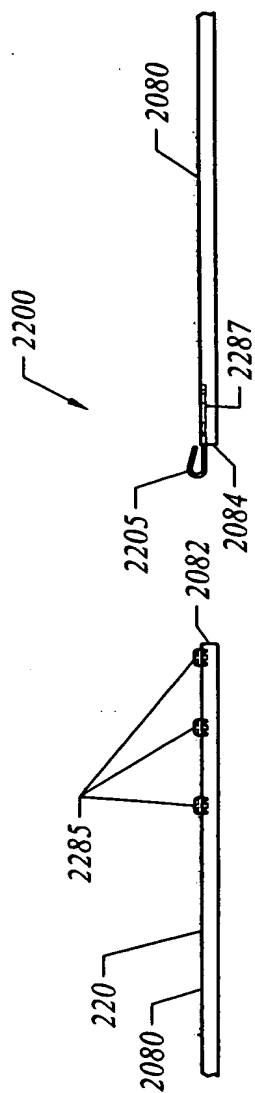


FIG. 40C

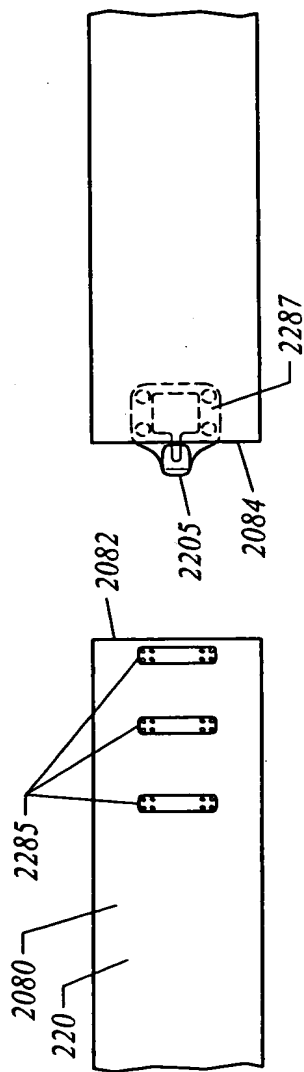
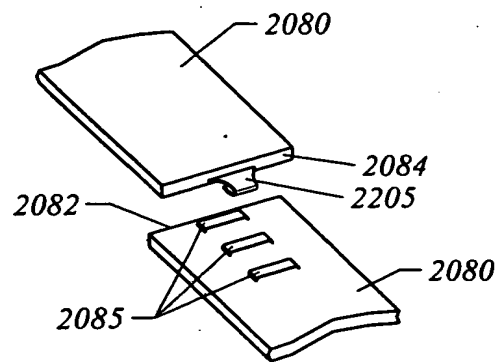
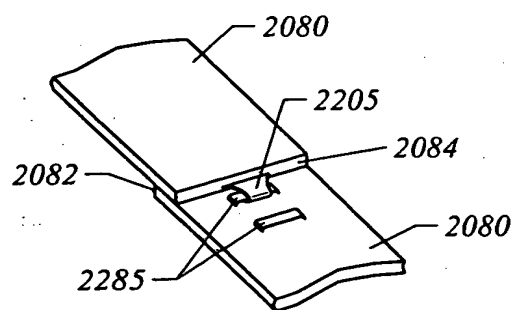


FIG. 40D

FIG. 40B



*FIG. 41A*



*FIG. 41B*

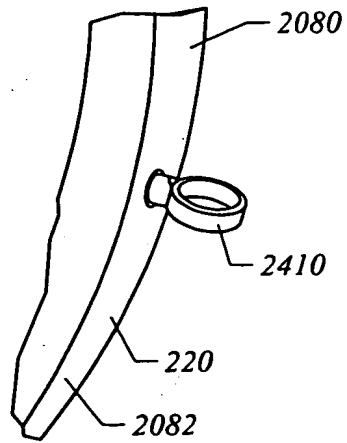


FIG. 42

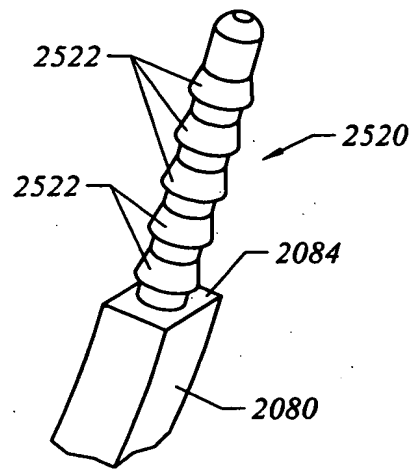


FIG. 43

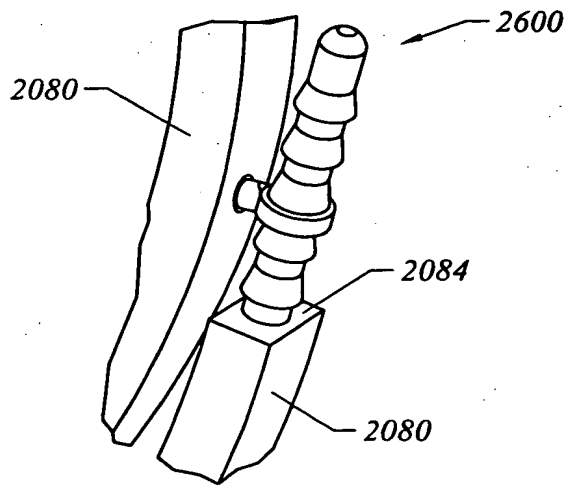


FIG. 44

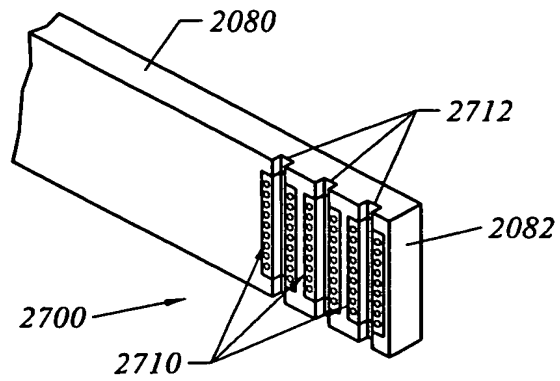


FIG. 45A

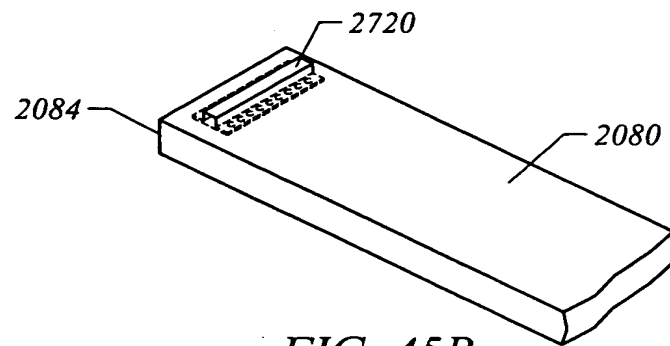


FIG. 45B

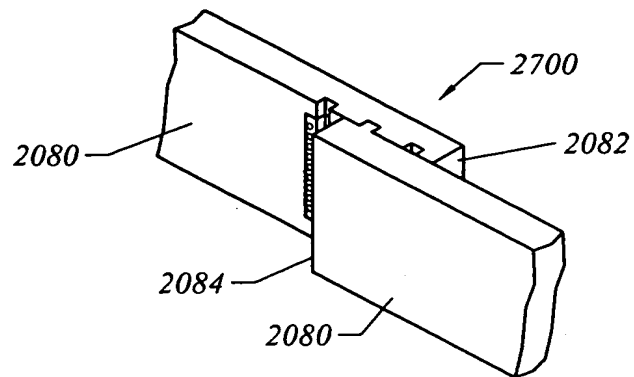
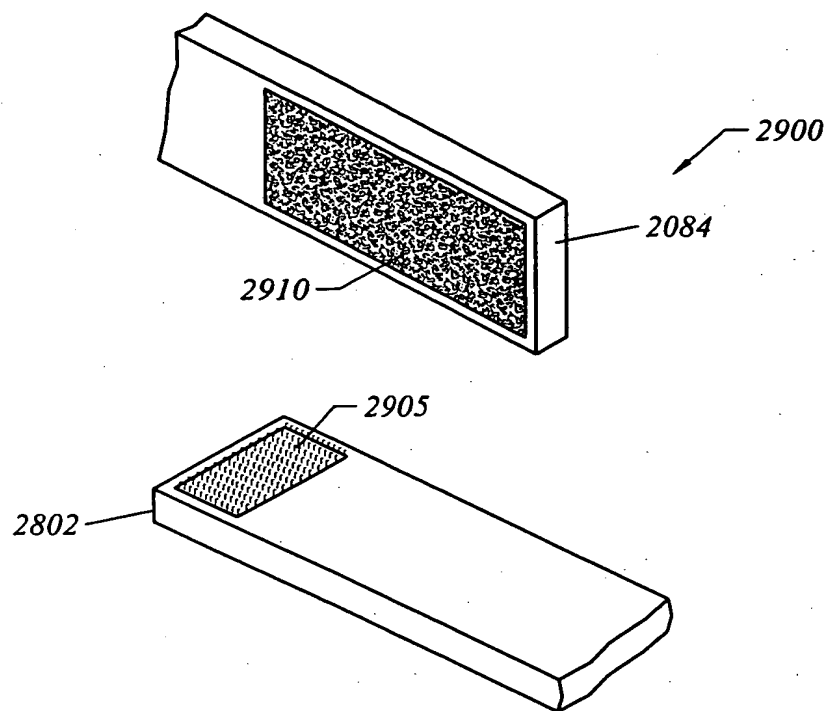


FIG. 46



*FIG. 47*

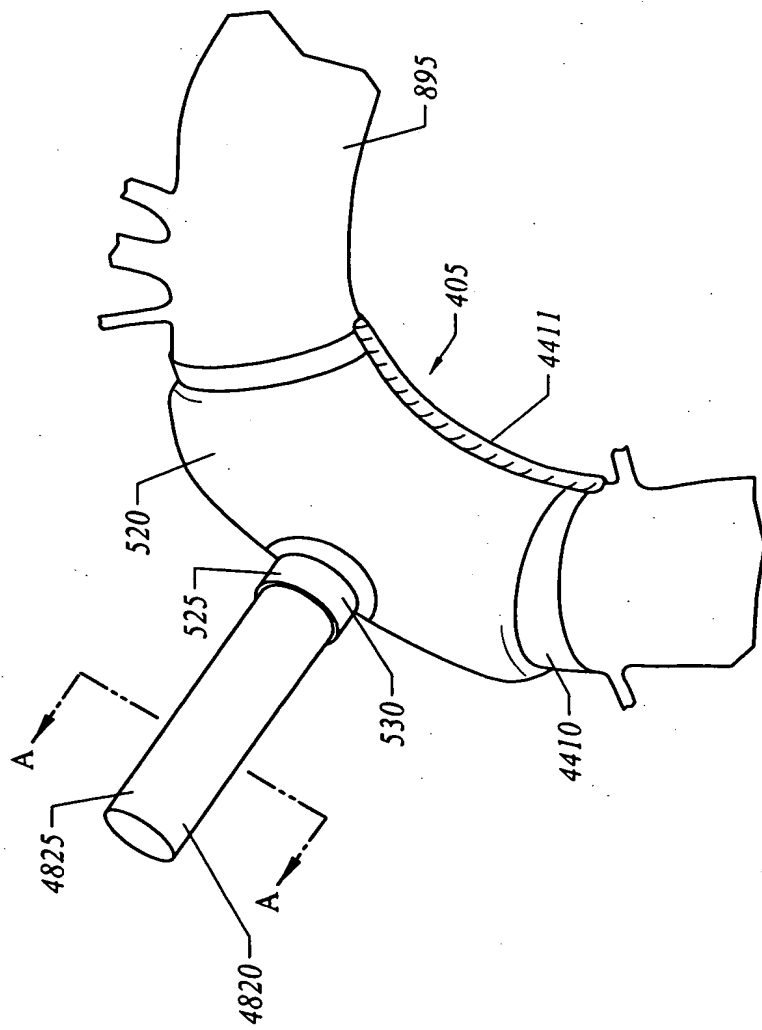


FIG. 48A

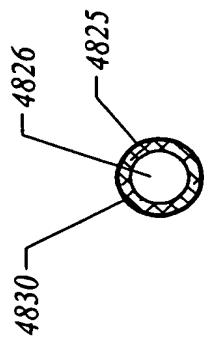


FIG. 48B

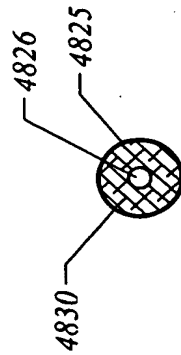


FIG. 48C

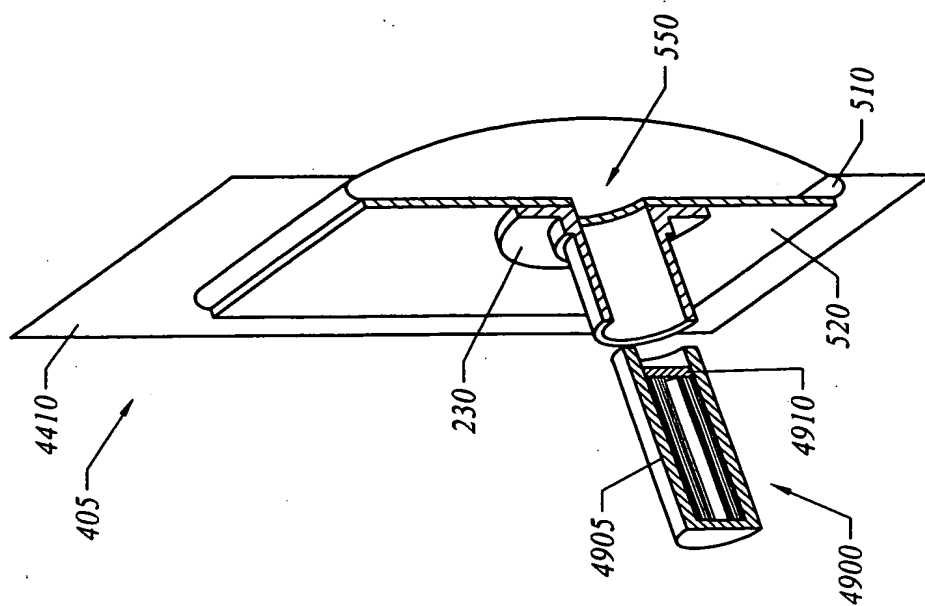


FIG. 49A

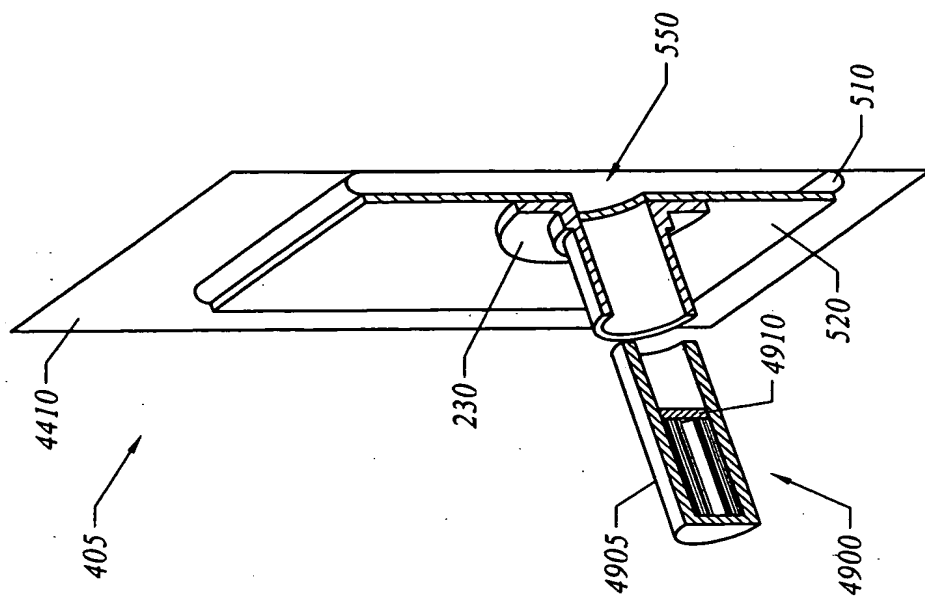
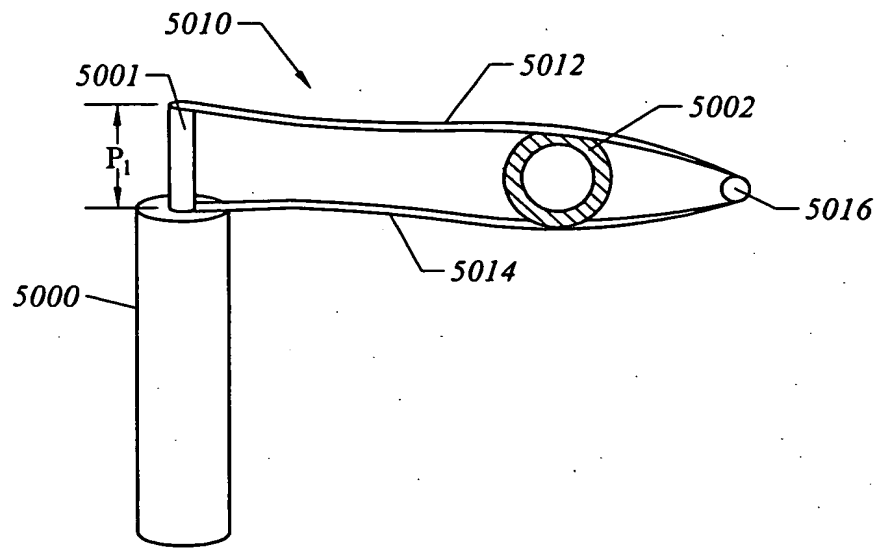
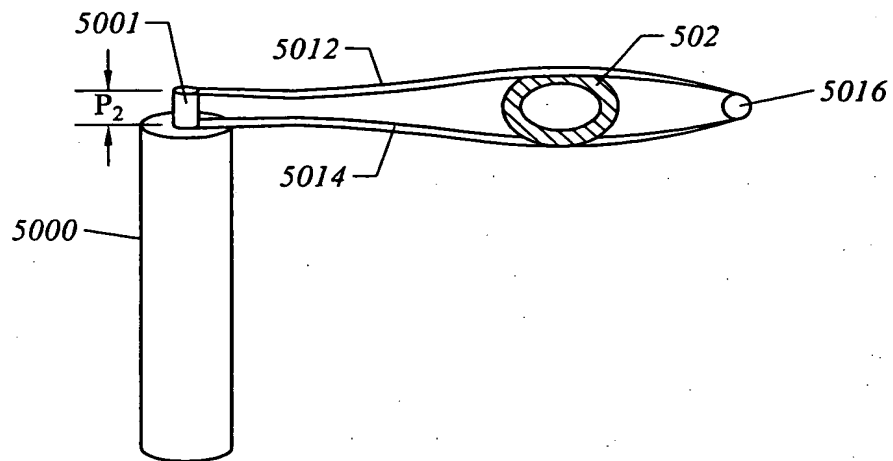


FIG. 49B

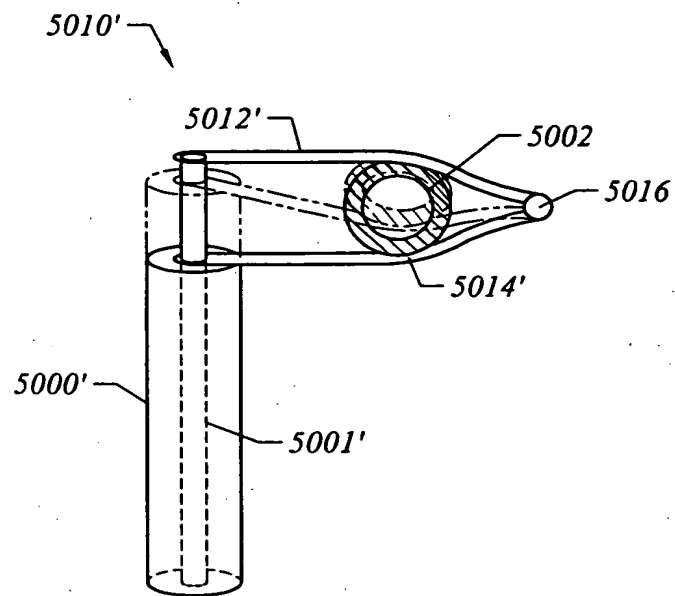




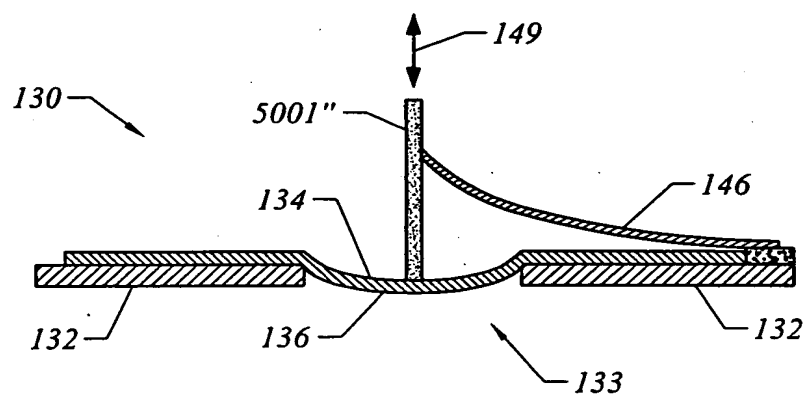
*FIG. 50A*



*FIG. 50B*



*FIG. 50C*



*FIG. 51*

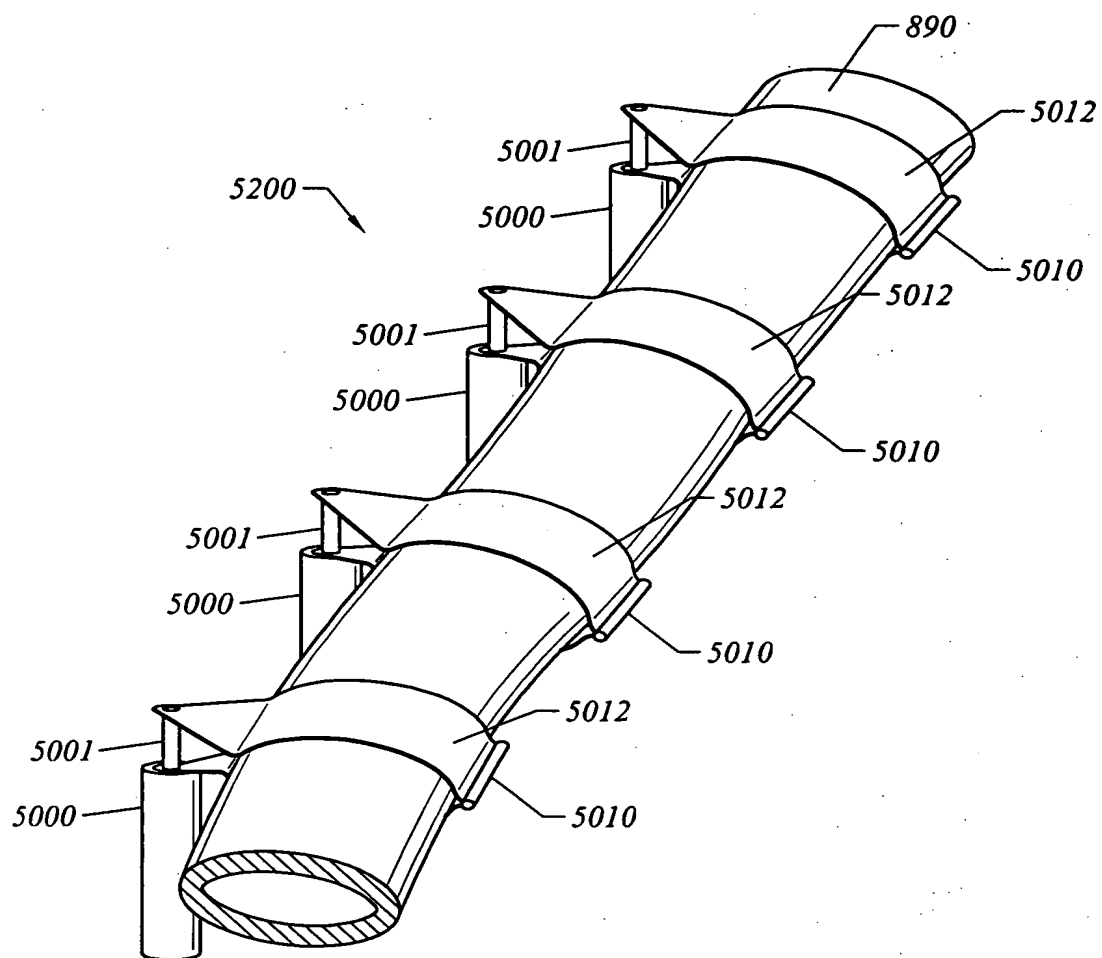


FIG. 52

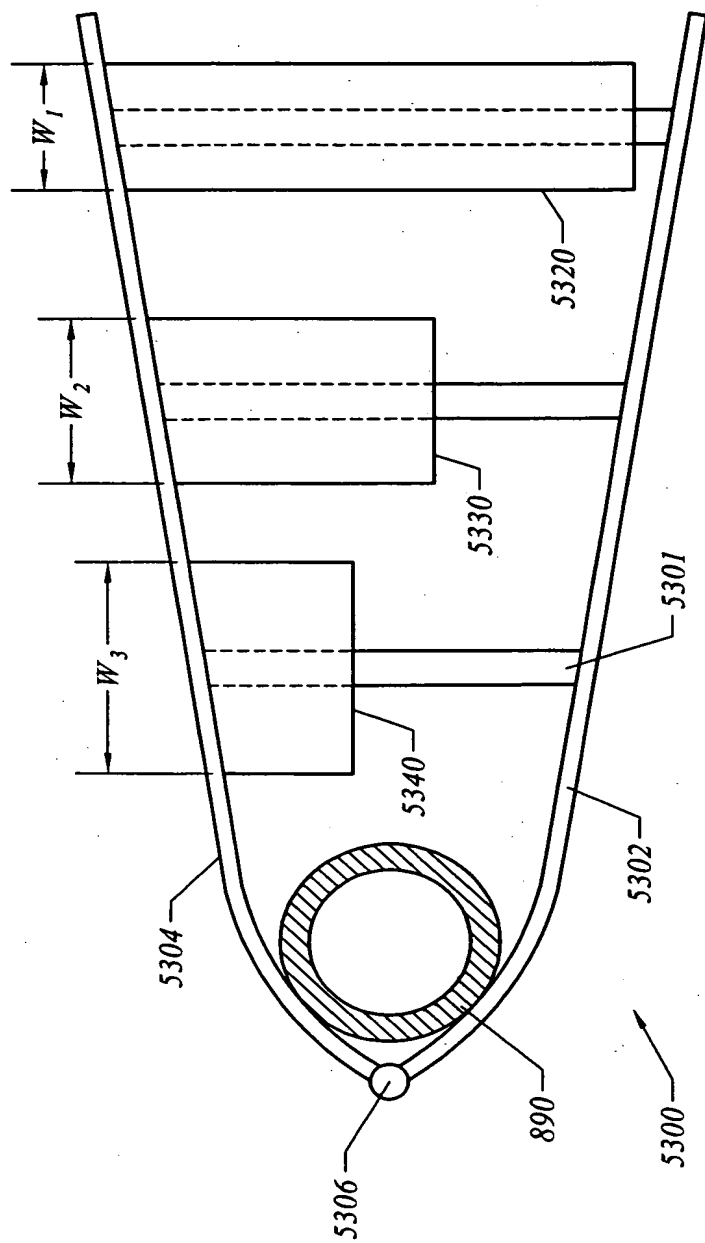
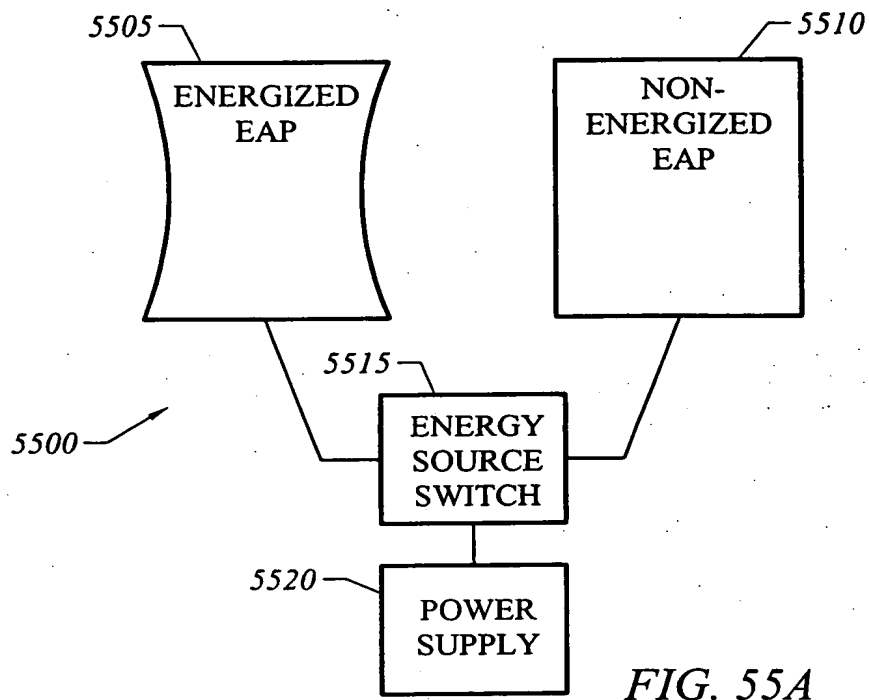


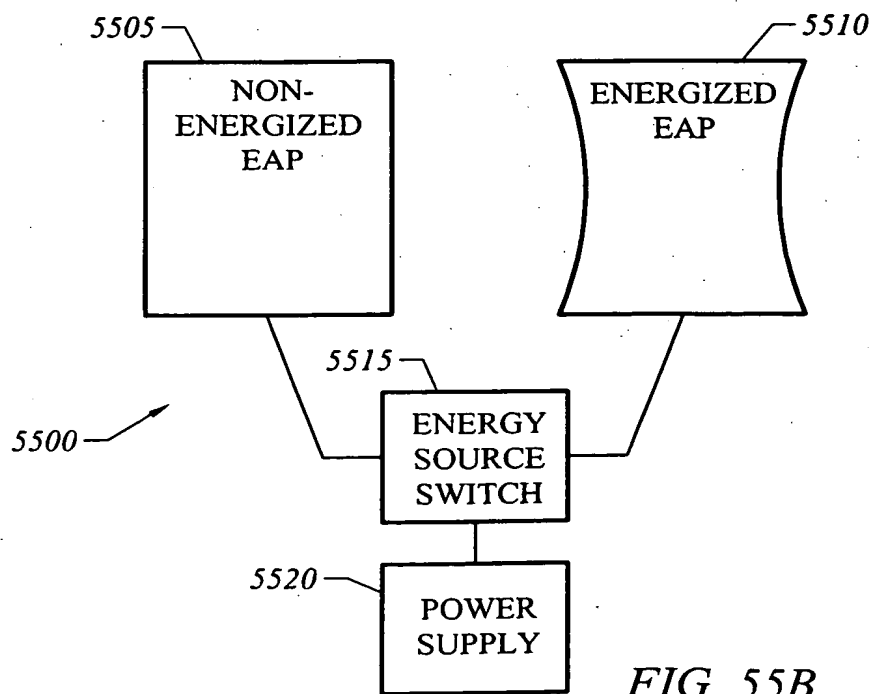
FIG. 53



FIG. 54



*FIG. 55A*



*FIG. 55B*

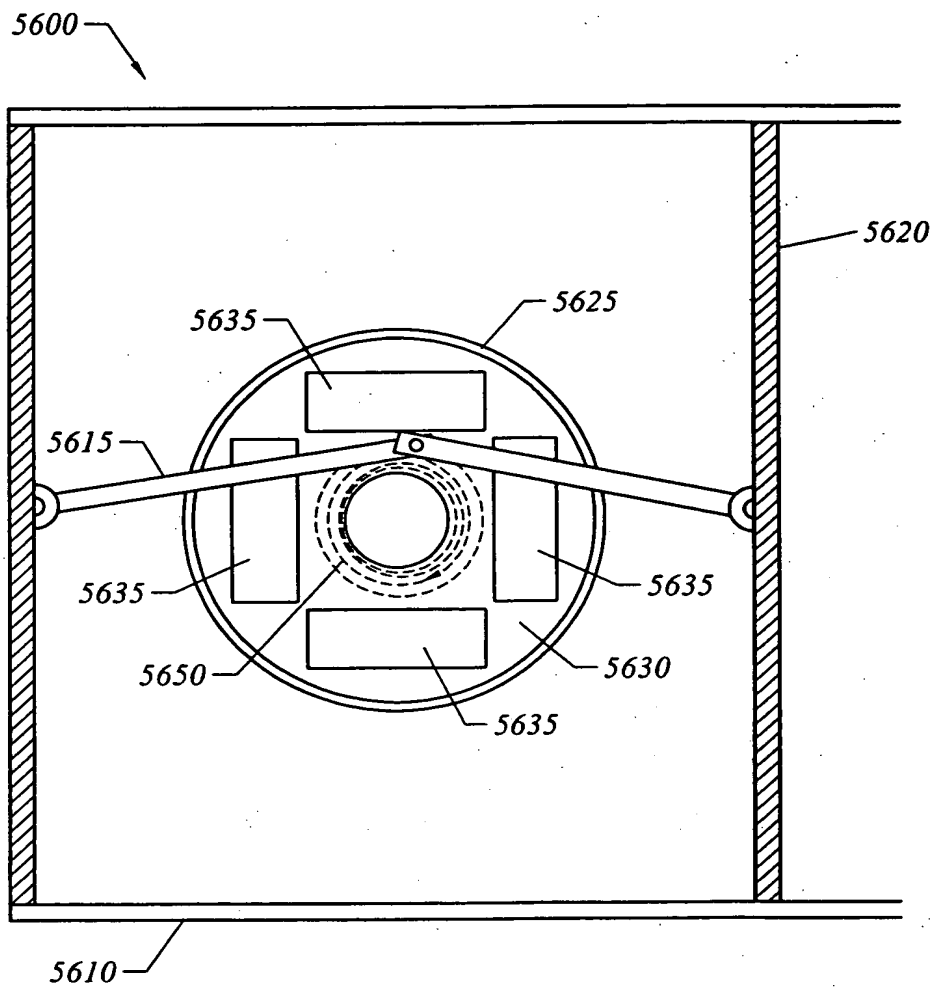


FIG. 56

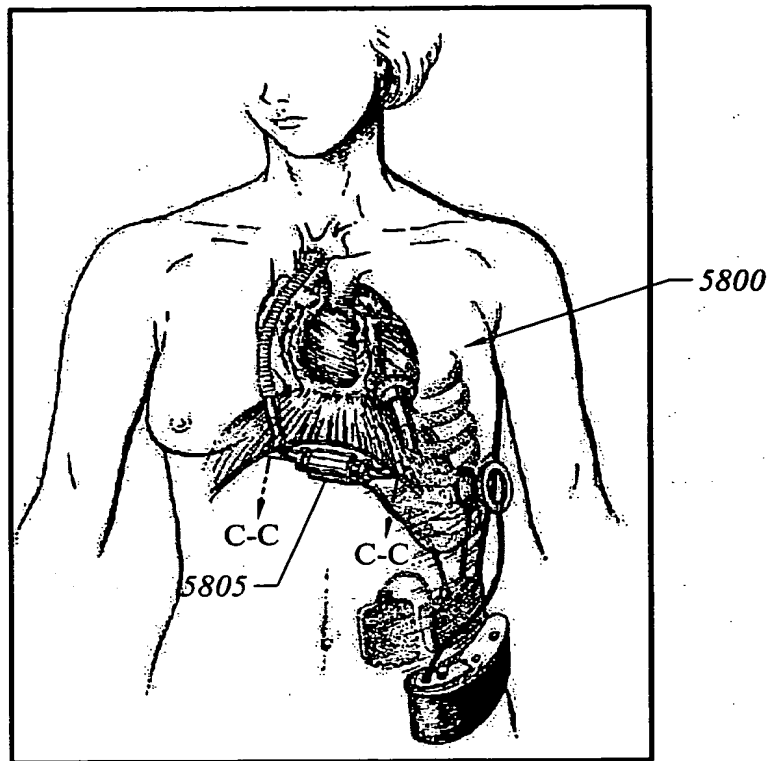


Comparison of Assist Device Technologies

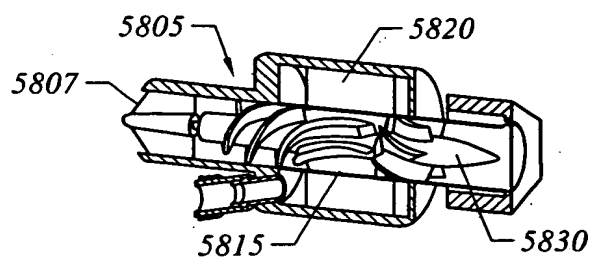
Description	Screw	Solenoid	Impeller	EAP
Flow	Pulsatile/Continuous	Pulsatile	Continuous	Pulsatile/Continuous
No. of moving components	Many	Many	Many	One (i.e. EAP layer)
Compliance chamber or exhaust	Required	Required	Not Required	Not required
Effects on blood cells	Safe	Safe	Lysis	Safe
Power required	15 to 30 Watts	20 to 45 Watts	8 to 12 Watts	3 to 5 Watts
Efficiency	≤30%	30 to 40%	≈50%	≥80%
Noise	Moderate	Loud	Moderate	Silent

Table C

*FIG. 57*

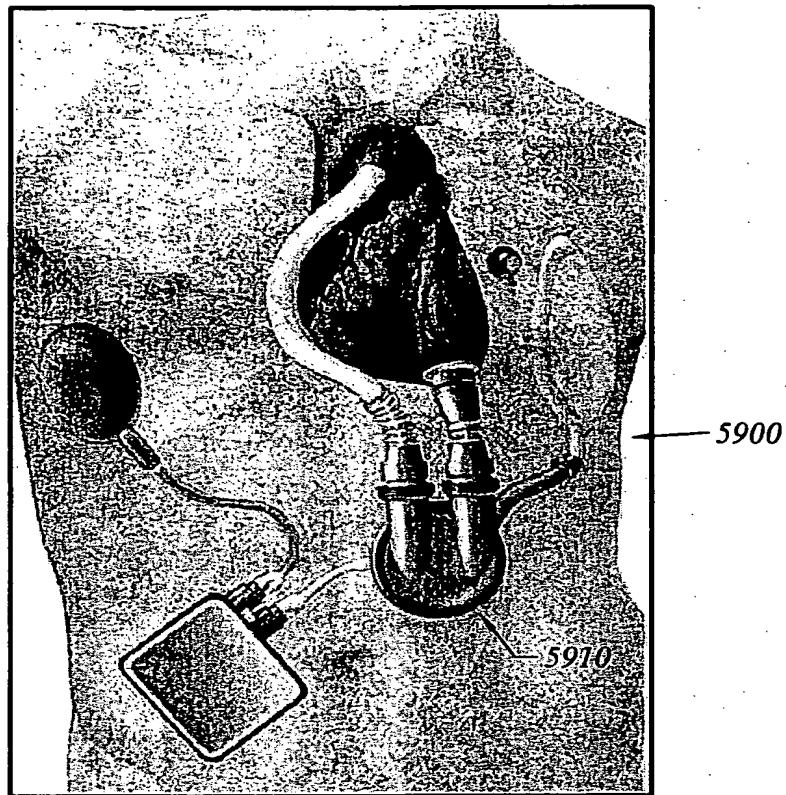


*FIG. 58A*

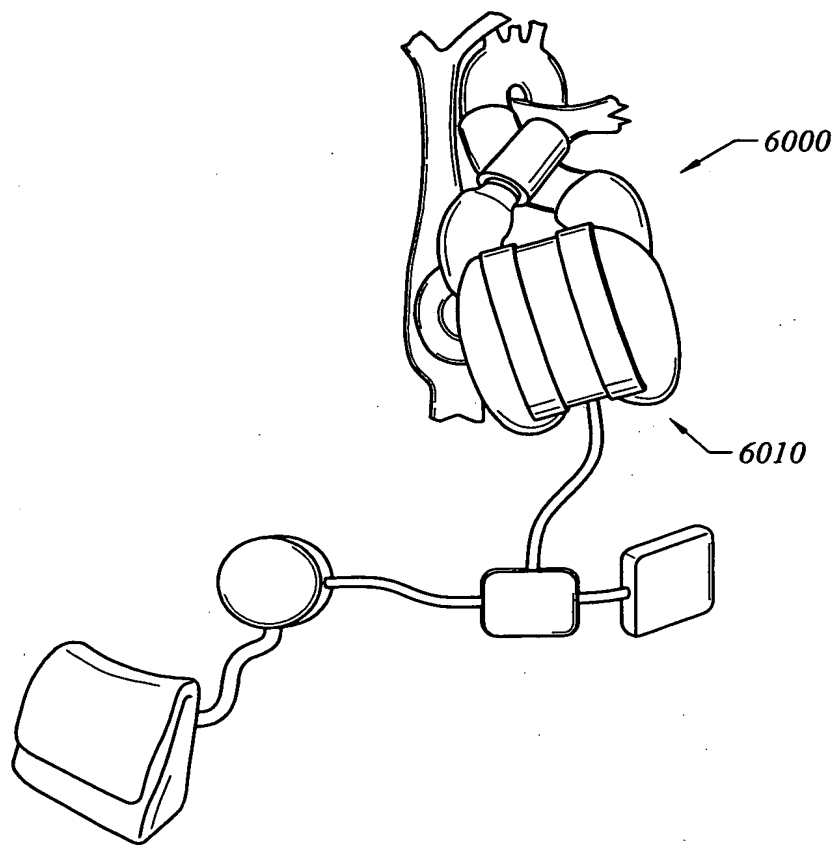


Section C-C

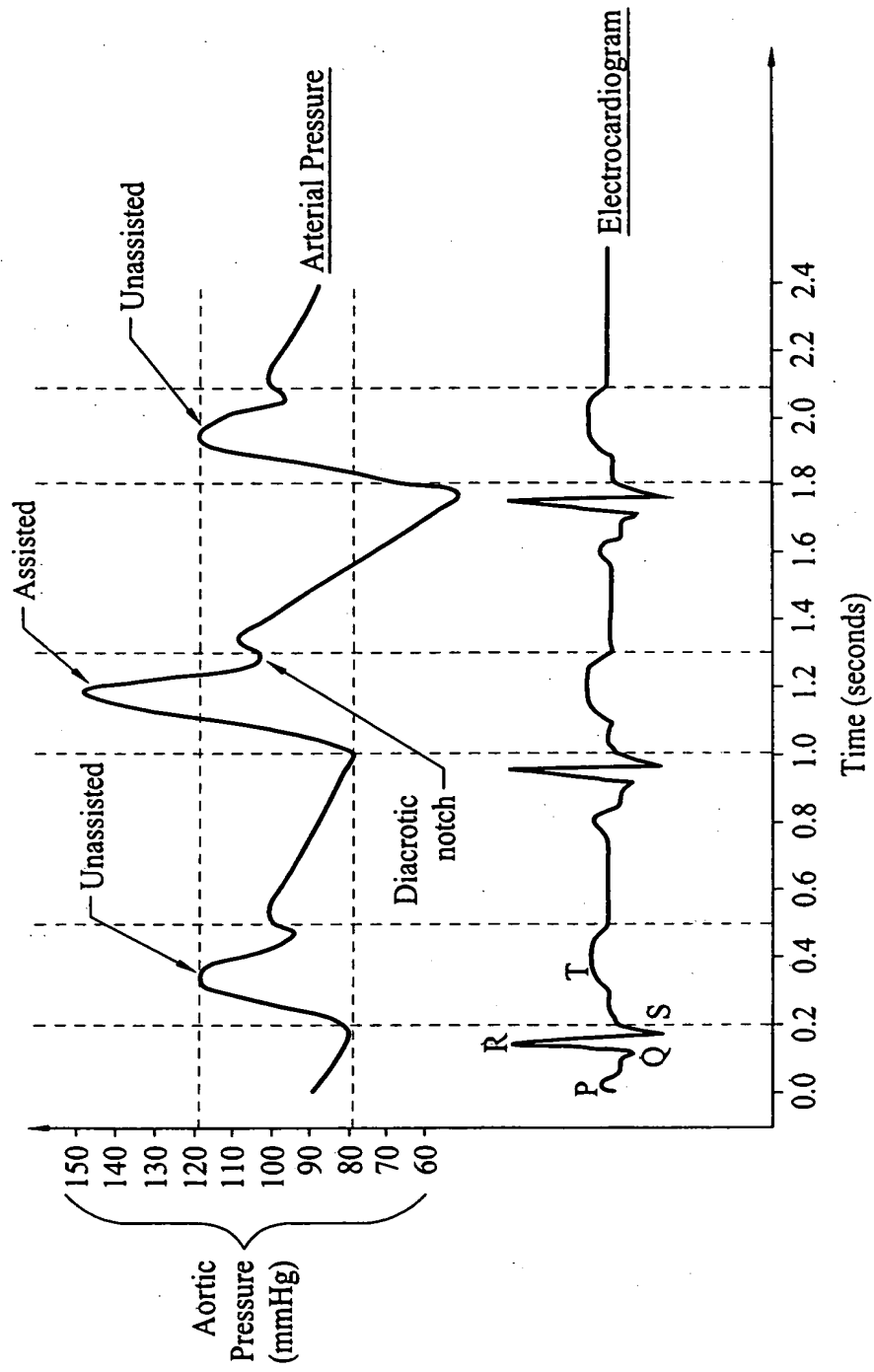
*FIG. 58B*



*FIG. 59*

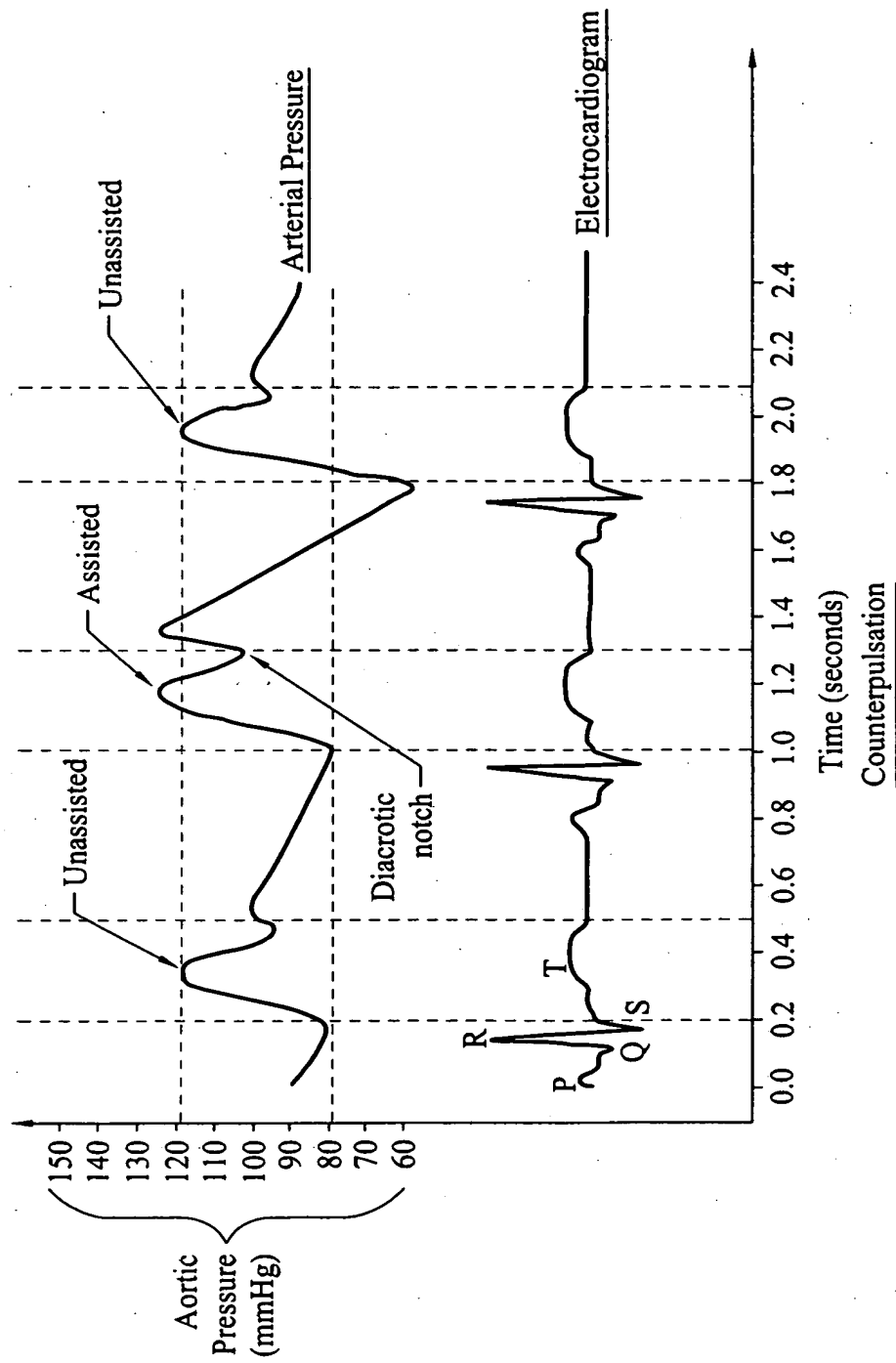


*FIG. 60*



Copulation

FIG. 61



**FIG. 62**